Physics

DISCOVERY

SEPTEMBER 1957 2/6

OCT 3 1957
UNIVERSITY OF ILLINOIS

The "ORTHOTRON"
4 Mev Electron Linear Accelerator

A compact and economic source of high energy electrons for Industrial Irradiation Techniques such as:

Controlled cross linking and degradation of long chain polymers.

"Cold Sterilisation" of pharmaceutical products and thermally unstable antibiotics even after final packaging.

Write for Special Publication 7210/5 and details of irradiation service for research and pilot plant purposes.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER 17

An A.E.I. Company

NR/506

NEW!

For price and performance Archimedes calculators have no rival. There is a full range of six models starting with the all-electric Model E priced £150

- Automatic SHORT-CUT Multiplication
- Storage Register with full carry-over
- Products accumulated positively or negatively in Storage Register
- Direct Transfer from Storage Register to Product Register
- Transfer from Product Register to Keyboard
- Plus all automatic features of the famous Archimedes range

See the **ARCHIMEDES TRIPLEX** before you buy your next calculator

Archimedes

For further details write to:

Archimedes-Diehl-Machine Co. Ltd.
Chandos House, Buckingham Gate, London, S.W.1
Telephone: ABBey 6397

Careers in Electricity

This is an extract from a recorded interview with E. O. Maxwell, an established C.E.A. engineer, aged 26.

"...in Power Stations I could get variety and responsibility"

Q.M.: **What first made you come into the Industry?**

Mr. Maxwell: I saw an advertisement for graduate training and it struck me that in power stations I could get the type of experience I wanted—variety and responsibility.

Q.M.: **Any particular reason why you chose this part of the world?**

Mr. Maxwell: Only that my people were living in the South of England so I voted to do my training here.

Q.M.: **After your training . . .?**

Mr. Maxwell: I was appointed Assistant Engineer—plant testing—Croydon B. My first ambition, of course, was to be in charge of a shift.

Q.M.: **Which you were. Weren't you a Charge Engineer before you were 23?**

Mr. Maxwell: Yes. Assistant two years and two months, then Charge Engineer. I was very keen on being responsible for staff and it suited me fine.

Q.M.: **What are your plans now?**

Mr. Maxwell: Well, my plan at the moment is to gain as much experience of the design and construction—construction side mainly—of nuclear power stations. Actually I shall be going, for two years, to one of the Atomic groups in about four weeks' time. My ultimate aim is really to get back into power stations.

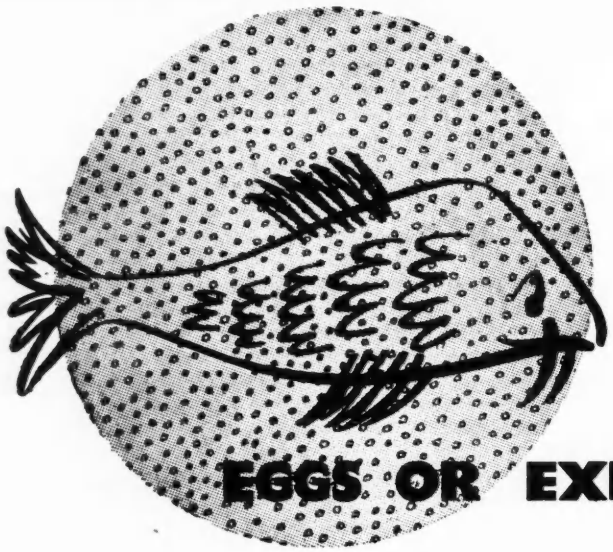
Q.M.: **You don't see yourself spending all your time in a nuclear power station?**

Mr. Maxwell: Oh, no. I'm much too young at the moment to specialise. I want to get as much general experience as I can.

We'd like to publish more of this interview, but there isn't space. For details of the many careers in Electricity and the salaried training schemes available, please write to:

The Education and Training Officer,
Central Electricity Authority,
15 Winsley Street,
London, W.1.

CEA



EGGS OR EXPOSURES

A famous writer once said that a photographer making exposures reminded him of a codfish laying millions of eggs in the hope that one or two would survive.

Be that as it may, it is still true that one of the great virtues of the camera to the scientist is its ability to produce any number of controlled exposures to order. In work of this nature, the unvarying quality of Ilford sensitised materials ensures that the results will be consistent, repeatable and comparable, time after time and from batch to batch.

ILFORD

The comprehensive range of speeds and characteristics of Ilford plates, films and papers covers needs of the scientist and research worker in every field of experiment.

PHOTOGRAPHIC MATERIALS

In the Service of Science

ILFORD LIMITED . ILFORD . ESSEX

DISCOVERY

EDITOR: Anthony R. Michaelis, Ph.D., B.Sc. EDITORIAL OFFICE: 244 High Holborn, W.C.1. CHAncery 6518
SUBSCRIPTION, DISTRIBUTION AND BUSINESS COMMUNICATIONS TO: Jarrold & Sons Ltd, Norwich. Norwich 25261
ADVERTISEMENT OFFICE: Aldridge Press Ltd, 27 Chancery Lane, W.C.2. HOLborn 8655

SEPTEMBER 1957 VOLUME XVIII NUMBER 9

CONTENTS

THE PROGRESS OF SCIENCE 365

- **Change or Decay**
- **The Discovery of Element 102**
- **Interplanetary Respectability**
- **New Crystalline Ice**
- **The Virus, Friend or Foe?**
- **A Case of Mechanical Eugenics**
- **Modern String and Sealing-wax**

TECHNOLOGY AND WORLD ADVANCEMENT 373
Presidential Address to the British Association
P. M. S. Blackett, F.R.S.

TECHNIQUES AND PROBLEMS OF REACTOR RADIATION CHEMISTRY 379
A. R. Anderson and J. K. Linacre

DEEP OCEAN CURRENTS 386
G. E. R. Deacon, F.R.S.

IMHOTEP THE FIRST SCIENTIST? 388
A. J. Arkell

SON ET LUMIERE AT GREENWICH 393
Andre Milon

LETTERS TO THE EDITOR 395

THE INTERNATIONAL GEOPHYSICAL YEAR: MONTH BY MONTH 396
Angela Croome

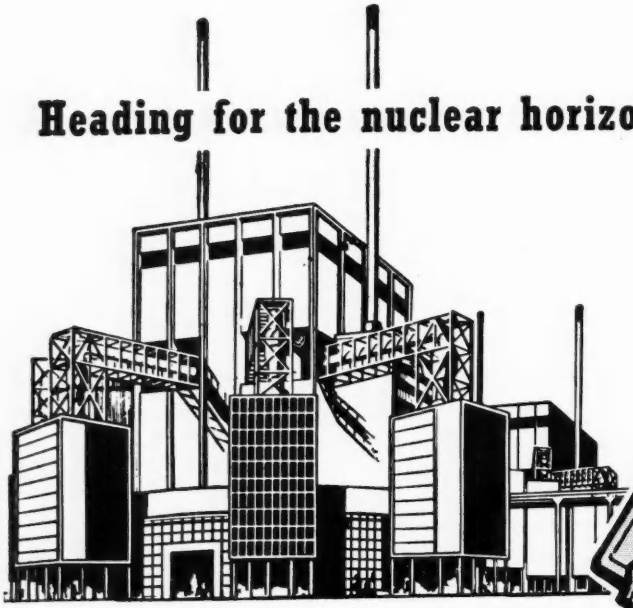
SCIENCE ON THE SCREEN 399

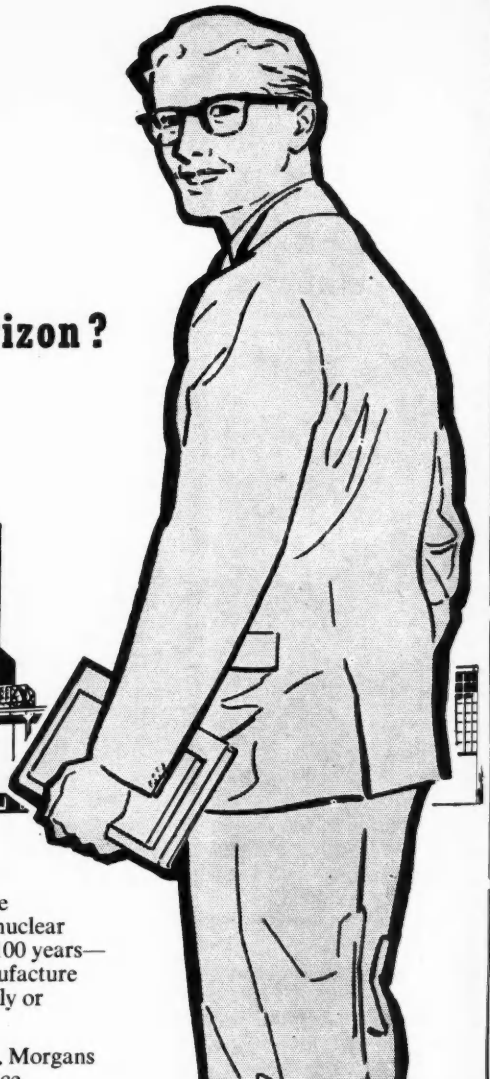
THE BOOKSHELF 400

FAR AND NEAR 405

COVER PICTURE: An artist's impression of the "pinger" in action with the *Discovery II*; see p. 386.

Heading for the nuclear horizon?





The chemists, engineers, metallurgists, physicists, technologists, and craftsmen of The Morgan Crucible Company are already going forward into the age of nuclear power. Morgans have dealt in progress for the past 100 years—using their knowledge and skills to develop and manufacture products, parts, and pieces which are essential, directly or indirectly to every industry throughout the world.

From laboratory research to commercial application, Morgans will always be in the forefront of the industrial advance.

MORGANS

CARBON AND GRAPHITE—ELECTRICAL, CHEMICAL, AND MECHANICAL; CRUCIBLES, FURNACES, REFRACTORIES; RADIO PARTS, SINTERED METAL PRODUCTS, AND ELECTRIC FURNACE ELEMENTS

THE MORGAN CRUCIBLE COMPANY LIMITED, BATTERSEA CHURCH ROAD, LONDON, S.W.11

MCC 124/A

BAT: 8822

THE PROGRESS OF SCIENCE

CHANGE OR DECAY

In the middle of the 19th century, when Britain supplied the world with over a third of all its manufactured goods, textiles formed nearly three-quarters of all our exports. By the beginning of the First World War this figure had fallen to a half; by the last war to under a third and, today, of a greatly increased total, textile exports represent under a tenth. On the other hand metals and engineering products today make up 54% of our exports; and exports of chemicals, particularly those based on petroleum, amount to 8%. Perhaps more significant than these fairly well-known changes in the overall picture of the goods which the world buys from Britain is the fact that, according to figures published by the Board of Trade, exports of goods which were either unknown or scarcely known before the war, or of which we exported little, now comprise a quarter of all our exports and so account for nearly half the expansion that has taken place in the last ten years.

These new or greatly expanded exports include such diverse products as chemicals and drugs, electronic equipment, combine harvesters, nylon goods, fluorescent lights, diesel engines for commercial vehicles, tractors, excavators and earth movers, and office machinery as well as ships, aircraft and motor cars; but the figures do not include some types of goods for which world demand is growing, such as electrical machinery, machine tools, and chemical and metallurgical plant, of some of which British exports are substantial.

There is nothing very surprising about these changes. It might have been expected that other countries, previously our customers, should build up their own industries, following the pattern of industrialisation which we had set in the last century. Nor is it surprising that the first factories of the developing East should be those making the simpler cotton textiles, and it would be selfish folly to refuse to allow India to sell her cloth in this country and so earn the currency with which to buy the plant and machinery she needs for her industrialisation. From us the world expects goods more difficult to make, for we cannot hope to maintain the standard of living of highly qualified technicians and continue to manufacture the products of the semi-skilled.

It is clear that in the future we shall do best by selling the world products that our customers have not yet learned to make; in other words, those including in their costs of manufacture a high proportion of scientific research and technological development. More and more these will be capital goods, for one of the features of consumer goods, including the durables, is that the "know-how" of their manufacture can be transferred to factories abroad where local labour can be quickly trained in the productive processes. For this reason it is extremely risky to rely on being able to export motor-cars. Fully mechanised plants are now operating in Australia, previously a customer for one-third of our car exports. India intends to make herself self-sufficient and even an exporter of cars within ten years' time, and factories are being set up by American and British manufacturers in South America.

On the other hand an examination of the plans of developing countries shows a common pattern of requirements; first, plant for transport and energy production; second, chemical and metallurgical plant; third, equipment for machinery manufacture and consumer goods industries. Of the loans so far made by the World Bank, 70% have been for transport and electric power generation. It is to the industries supplying these needs, together with the ancillary industries making telecommunications equipment and instruments, that we must look in the future to safeguard our foreign earnings and thereby our essential imports; but if they are to do so they must remain technically competitive, for one of the main features of these industries is that they are subject to rapid technical advance based on scientific research.

On the whole we can be satisfied that some of these industries—such as aircraft manufacture, electrical and chemical plant manufacture (including nuclear plant), and the developing industries based on electronics—are well aware of the need for an adequate expenditure on research and development; but there are other industries, of prime importance to our economy and with great potential for expansion, which are lamentably backward in this field.

According to the recently published report on Scientific and Engineering Manpower in Great Britain, whereas in such industries as Electrical Engineering and Aircraft Manufacture there are two qualified scientists or engineers for every hundred employees, in shipbuilding and motor manufacture the proportion is a mere 0·4%. Unfortunately the breakdown of the mechanical engineering industry is not sufficient to enable comparisons to be made between different sections of it, but one spokesman for the machine-tool industry claimed recently that it only needed engineers recruited directly from the shop floor. The shipbuilding and machine-tool industries point to their long order-books as proof of their efficiency; but in fact this may simply be proof of their conservatism. Certainly when the climate becomes more competitive they will suffer if they are not now doing the research and development on which their future depends.

The education and training of scientists and engineers, as well as their employment in laboratories, are essential features of any long-term plan for British industry. The reduction in defence expenditure will, according to the Government White Paper, release more of these badly needed people for civilian industry, and firms which fail to take advantage of their availability now may well find their fortunes declining in the not very distant future.

THE DISCOVERY OF ELEMENT 102

The discovery of a new element has always held a fascination for chemists, and the scope for such fresh discoveries is nowadays severely restricted. The new element is number 102 in the series. It is the tenth

beyond uranium, which as number 92 for long formed the limit. During the 1930–40 decade came the chain of discoveries culminating in the development of atomic energy, and as part of that development, the production of the "transuranium elements", including especially plutonium. All the nine transuranium elements up to 101 were first identified in the U.S.A.; number 102 is the first to originate on European soil.

Nevertheless, America had a key part in the production of 102, because it was the Argonne National Laboratory near Chicago that supplied the essential starting material. Two of the radiochemists from that laboratory, Dr Fields and Dr Friedman, came to Harwell and Stockholm to help in the work. Sweden made an equally important contribution, because the Nobel Institute's cyclotron is the best in Europe for the task in question. Four of the Institute's staff, Drs Atterling, Forsling, Holm, and Åström, played a major part. Finally, Harwell acted as a base for handling the radioactive material and as a source of various special equipment needed in Stockholm.

Making the new element required the utmost in available resources and techniques. It was a task to catch the imagination, like the four-minute mile or climbing Everest. For the time being it marks the limit of the possible.

There has indeed been a slow upward ascent from uranium—which is the ultimate starting-point for all the transuranium elements. If we continue the simile of Everest, uranium represents the base camp, and each new element on the way represents a new camp from which one can strike upwards again. One has to accumulate sufficient supplies at a high point before one can tackle the next objective. And at element 102 the atmosphere is getting pretty rarefied.

The first steps up from uranium are neptunium and plutonium, elements 93 and 94. When these elements were first prepared, the quantities were unweighably small. It is a measure of our progress since then that the world's total production of plutonium in nuclear reactors must now be reckoned in tons.

From plutonium we can take the next step, to elements 95 and 96, americium and curium. This became possible towards the end of the war, when sufficient plutonium had been manufactured. And so, stage by stage, the advance has gone on.

The starting material actually used in Stockholm consisted of curium-244. The quantity available was only 5 milligrams, or about as much as a small pinch of salt. This had been prepared by irradiating plutonium for about two years in the only reactor powerful enough for the job, the Materials Testing Reactor in Idaho. At Harwell, the curium was painted, skilfully and tediously, on to thin aluminium foils, about a milligram to a foil. The foils were sent by air to Stockholm for use as "targets" inside the cyclotron.

The particles used in the Stockholm cyclotron were heavier than those commonly employed. They were indeed carbon-13 ions, and it was this that made the big jump from element 96 to 102 possible in a single stage. The chance of making 102 was latent in the experiments from the start. Conditions must, however, be just right; in particular, the energy of the bombarding particles must be neither too low nor too high.

Naturally enough after the bombardment, the products must be examined and identified. This calls for a complicated electronic equipment and a highly refined chemical separation process. The electronic device mentioned might be described as a glorified Geiger counter. It sorts out the impulses normally heard as clicks, and counts the different kinds separately. It is a matter of the energy of the radiations; each is fed into its appropriate channel in the apparatus, which is called a "kick-sorter".

When the products from the curium bombardment were tested on the kick-sorter, a few "events" were observed in a particular channel corresponding to a high energy. These events were painfully infrequent. Many bombardments gave none at all, some gave one, some two, and on one glorious occasion there were four. But though infrequent, the events were distinctive, and as their number grew, the possibility of their being accidental could be rejected.

A few atoms of a new species were unmistakably being produced. The new species was characterised by the energy of the particles it emitted (alpha-particles of 8·5 million electron-volts) and by its rate of decay (half-life, about 10 minutes). But was it element 102, or was it an isotope of some element already known? This was a chemical question.

A technique exists now which is rapid, sensitive, and conclusive. It must be rapid, because one is limited by the 10-minute half-life, it must be sensitive, because one has only a few atoms to deal with, and it has to distinguish element 102 from all other likely elements. The technique employs ion exchange. When the material from the Stockholm cyclotron bombardments was investigated by this technique, it was found that the high energy events turned up in a drop of the outflowing liquid corresponding to element 102. The last link had been forged in the chain of evidence.

The discoverers, including Dr Milsted from Harwell, nevertheless remain cautious. Their evidence is, so far as can be seen, complete and conclusive. Yet it rests on less than twenty events of a highly abstruse kind, and they naturally hope that confirmatory results will be obtained by other scientists.

If anyone should ask what is the use of such research, one might well retort by asking what is the use of climbing Everest. Even on a strictly utilitarian basis, tasks which force us to develop our techniques to the limit have their value. In a field like nuclear science, indeed, any addition to our knowledge may have unexpectedly wide significance. Yet it is surely not the calculation of possible benefits that provides the real motivation. All scientists feel that new discoveries are worth while for their own sake, and they are prepared to devote their lives to achieving them.

INTERPLANETARY RESPECTABILITY

At the College of Aeronautics, on July 18, 1957, the British Interplanetary Society graduated from the status

of an amateur body to that of a professional scentific society. On that day, the first British Symposium on High Altitude and Satellite Rockets was opened by Prof. H. S. W. Massey, F.R.S. with a paper on the scientific uses of rockets and satellites. The high scientific level of his contribution and the following discussion was maintained throughout the whole meeting. The symposium was jointly organised by the British Interplanetary Society, the Royal Aeronautical Society, and the College of Aeronautics; it was attended by over 150 scientists from government departments, universities, and industry. The presence of distinguished teams of American and Russian scientists put the meeting on a professional scientific basis. At the symposium dinner, Air Chief Marshal Sir Philip Joubert de la Ferté made a charming speech comparing the early history of aeronautics with that of rocketry, and Sir George Edwards, the Managing Director of Vickers-Armstrongs (Aircraft) and President of the Royal Aeronautical Society gave the blessings of industry, although he personally refused to do anything more than promise to learn the new jargon. It seems indeed a long time ago since the first enthusiasts met to promote interplanetary travel!

The subjects of the symposium papers ranged widely. Dr M. Rosen, of the U.S. Naval Research Laboratory spoke about the Earth Satellite Programme of which he is in charge; that he was able to take the time off and come to England for this meeting speaks well for the progress of this vast scientific and technological project. The British rocket, the *Skylark*, was fully described for the first time by W. H. Stephens of the Royal Aircraft Establishment, Farnborough; again it was the man-in-charge who described his work. Prof. A. D. Baxter, of the College of Aeronautics who had done so much to make this meeting possible, discussed the propulsion problems of high altitude rockets, and the many design difficulties of large missiles were described by K. J. Bossart, the technical director of Convair Astronautics; his company now holds one of the leading positions of rocket design and manufacture in the U.S.A. Perhaps the most novel idea submitted to the symposium came from Dr W. G. Hilton of Armstrong Whitworth Aircraft Ltd. To solve the extremely difficult problem of cooling a rocket vehicle re-entering the atmosphere, he suggested a shape and form, which can only be described as an upside-down spinning saucer, with the human occupant on the underside. His mathematical calculations indicated that this vehicle, entering the atmosphere at an angle of 45° would produce a vacuum on its lower surface which would keep the occupant within possible temperature limits. From the Russian team, headed by Prof. B. M. Petrov, came a full statement of their plans to use rockets and satellites during the IGY. It was the first indication to the West of their detailed intentions. This is fully discussed on page 396 of this issue. The proceedings of the symposium will be published as a monograph.

In the hangars of the College, a small but excellent exhibition of "hardware" completed the picture given by the scientific papers. Noteworthy was a sectioned example of the French *Veronique*, seen for the first time in this country; it was a medium size, liquid fuel rocket, propelled by the combustion of fuel oil and concentrated nitric acid.

It must have given the organisers of the symposium great satisfaction that their very young subject attracted such excellent scientific papers and exhibits. The fact that so many distinguished scientists from overseas and this country attended it has made the subject of interplanetary flight respectable.

NEW CRYSTALLINE ICE

While the properties of ice have been the subject of numerous investigations, there are still surprising gaps in our knowledge. The structure of ice was studied by x-rays in one of the early investigations, where it was established that the oxygen atoms are in a certain type of hexagonal arrangement, such that each of these atoms has four oxygen atoms as neighbours. The question of how the hydrogen atoms are distributed has been the subject of experiment and of argument for many years, and even now there is by no means a generally agreed answer.

It has, however, always been taken for granted that there is only one crystal form of ice at or below atmospheric pressure and at all temperatures for which a solid form exists. It is true that a number of claims have been made by physical chemists that cubic forms of ice have been produced; these forms have invariably been associated with organic substances, and it seems probable that they are, or arise from, some hydrated form of organic compound. In any case, the density of these forms differs markedly from that of normal ice.

Other forms of ice are known to exist at high pressures. Extensive investigations by P. W. Bridgman up to pressures of fifty thousand atmospheres have shown a number of additional types; these have been arranged in a series from I to VII, the first being the normal form at ordinary atmospheric pressure.

It has therefore been surprising that a new form of ice has been definitely shown to exist, at present at low temperatures and at low pressures. The first evidence of this was produced in 1942 by H. König,* working at Göttingen, during an investigation of substances at low temperatures using an electron diffraction camera. It was found that a contaminating layer appeared at low temperatures which could be reduced only by carefully drying the apparatus. It was found that a layer of this contamination gave a diffraction pattern consisting of two or three diffuse rings. When the layer was warmed the pattern changed to one consistent with a cubic form of ice, in which the oxygen atoms are arranged as in the diamond structure, each atom having four neighbours (Fig. 1). On further warming, the diffraction pattern underwent a further change at about −80°C, and was then consistent with ice of normal crystal structure. A detailed study of the relation of the diffraction patterns (Fig. 2) showed that the two forms had substantially the same density.

During the past year the results of two independent

* König, H., *Z. Kristallogr.*, 1944, vol. 105, p. 279.

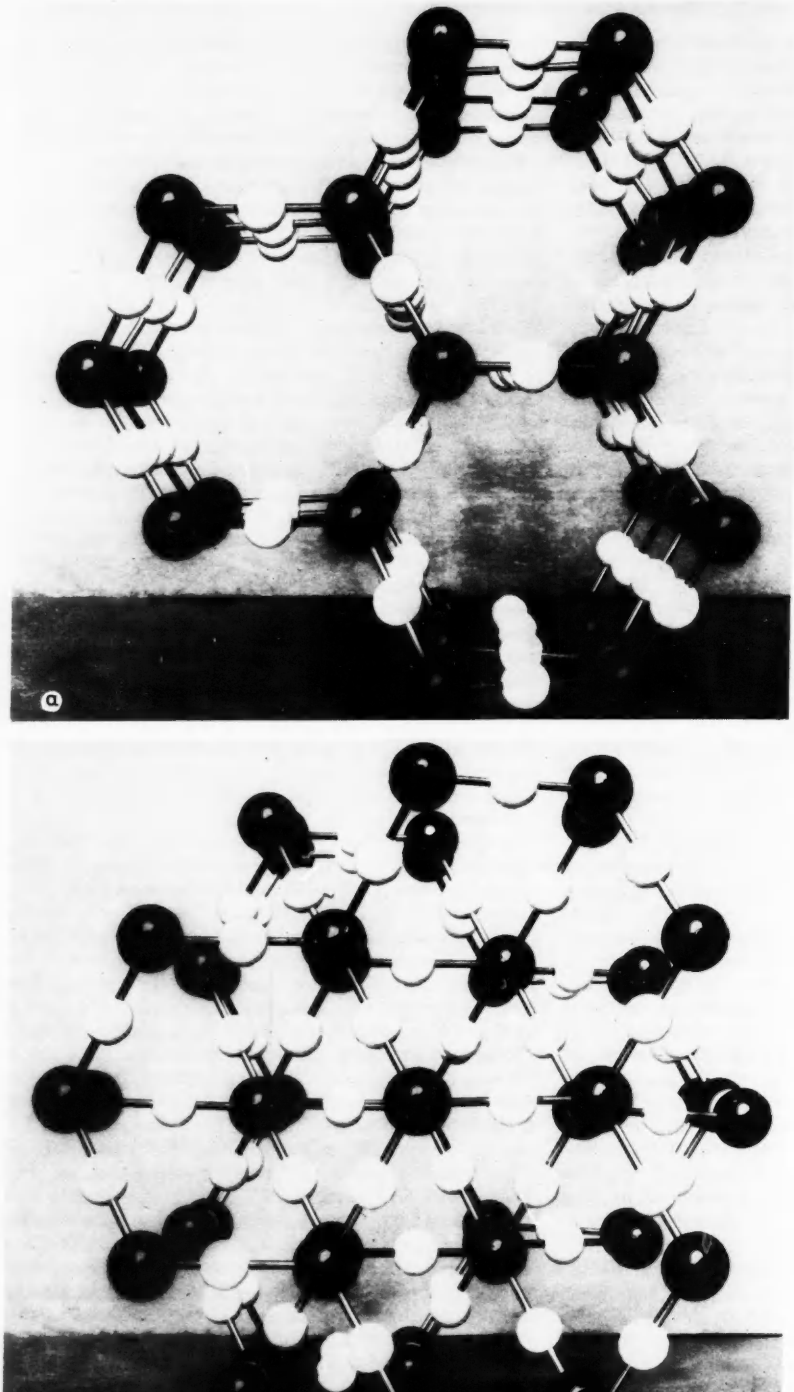


FIG. 1. The two forms of ice (*a*) hexagonal, (*b*) cubic. In these the large spheres represent the oxygen atoms, the small spheres the hydrogen atoms which are arbitrarily placed at the centre of bonds between the oxygen atoms. The two models are photographed from equivalent directions.

investigations, one* carried out in the physics department at the Imperial College, London, and the other† in Japan, have been published, in which the production of the cubic form of ice has been examined in more detail. In these, the new form of ice was produced directly from water vapour injected into an electron diffraction apparatus; care was taken to see that the apparatus itself was sufficiently dry so as to produce no contamination during the time of an experiment. In this way one can be quite certain of the origin of the deposit. Two methods of forming cubic ice can be used. It can be produced directly from water vapour by condensation on to a suitable surface in vacuum at a temperature which lies between $-150°C$ and $-120°C$. Above this temperature region the normal hexagonal form is found; below it, the deposit gave a diffraction pattern consisting of a few diffuse rings which might be expected from supercooled water (though other explanations are also tenable). The second method of forming cubic ice is to heat this deposit, the method originally used by König. The deposit changes into cubic ice at about $-120°C$, the change taking place in a temperature interval of a few degrees. The existence of the cubic form was also demonstrated when "heavy water" was used as the source of the vapour. The temperature region in which this was formed was substantially the same as when ordinary water vapour was used.

In all these investigations cubic ice was formed at a very low pressure and in very thin layers (about a ten thousandth of a centimetre in thickness) since it is experimentally impracticable to study thicker layers of cubic ice in an electron diffraction camera. So far, the cubic form has not been produced in bulk, though there seems to be no reason to doubt that this can be done. The main precaution needed is to ensure that the time of formation of the deposit is sufficiently long. Whichever method is used, there is necessarily a heat release when the vapour is condensed to form a deposit. If the formation is too rapid, the deposit will be heated to the temperature at which hexagonal ice is formed ($-80°C$). Investigations have in fact been carried out in which the cubic form ought to have been produced; it is probably due to the high speed at which the deposit was formed that cubic ice was not discovered earlier.

Once cubic ice is produced in bulk and its thermal and other properties have been measured, it will be possible to decide its status with respect to ordinary ice. At present it is not clear whether it belongs to the series of Bridgman's seven forms, in which case one would have to label cubic ice as Ice 0 (since I to VII are allocated) or whether it should be given a special classification (possibly Ice A) as a metastable form.

THE VIRUS, FRIEND OR FOE?

Recent research on plant viruses by Schramm, Schumacher, and Zillig (1955),‡ Fraenkel-Conrat and Williams (1955 and 1956),* Commoner, Lippincott, Shearer, Richman, and Jia-Hai (1956),† and others, reviewed in the *British Medical Journal* (1957) hold out exciting possibilities for the future. The virus most extensively investigated is tobacco mosaic virus which is a hollow rod-shaped virus, made up of a concentric zone of nucleic acid strands surrounded by protein units arrayed in a flat spiral. This virus was first separated into two fractions, ribonucleic acid and protein. The protein was separated by alkaline precipitation with ammonium sulphate, and the ribonucleic acid by treating the virus with detergent. These fractions were not themselves infective, but, when mixed, rods resembling those of tobacco mosaic virus were formed, and about 3% of these were infective, producing lesions identical with those of tobacco mosaic virus. Within strains of tobacco mosaic virus, different combinations of the protein from one strain with the ribonucleic acid from another indicated that genetic control of all observed symptoms lay in the ribonucleic acid fraction. The combination of standard tobacco mosaic virus protein with the ribonucleic acid from Holmes ribgrass strain of tobacco mosaic virus produced a virus which was serologically tobacco mosaic virus and had the characteristic symptoms of Holmes ribgrass in the plant. The progeny from this virus, however, had protein as yet indistinguishable from Holmes ribgrass. The ribonucleic acid from normal tobacco mosaic virus

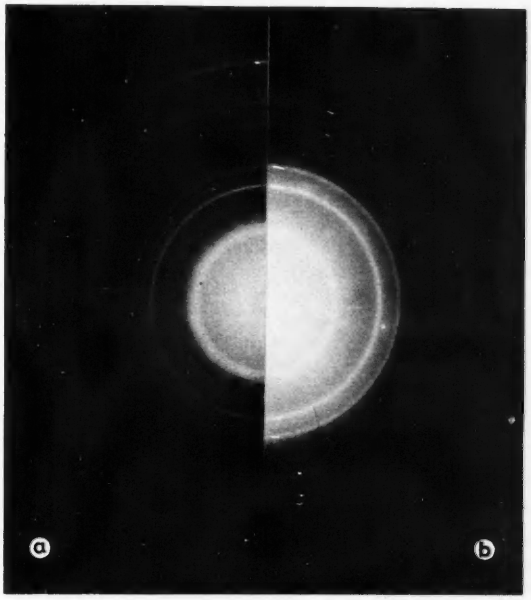


FIG. 2. Electron diffraction patterns from (*a*) hexagonal ice, and (*b*) cubic ice.

* Blackman, M., and Lisgarten, N. D., *Proc. roy. Soc. A*, 1957, vol. 239, p. 93.

† Honjo, G., Kitamura, N., Shinaoka, K., and Mihama, K., *J. phys. Soc., Japan*, 1956, vol. 11, p. 527.

‡ Schramm, G., Schumacher, G., Zillig, W., *Nature*, 1955, vol. 175, p. 549.

* Fraenkel-Conrat, H., and Williams, R. C., *Proc nat. Acad. Sci. Wash.*, 1955, vol. 41, p. 690; Fraenkel-Conrat, H., *J. Amer. chem. Soc.*, 1956, vol. 78, p. 882.

† Commoner, B., Lippincott, J. A., Shearer, G. B., *Nature*, 1956, vol. 178, p. 767; Richman, E. E., and Jia-Hai, W., *Nature*, 1956, vol. 178, p. 767.

has been separated into three fractions, each of which, when combined with normal tobacco mosaic virus protein and inoculated into plants, produced symptoms widely different from those of normal tobacco mosaic virus. Thus *in vitro* manipulation of the genetic material produced three new viruses.

Where do we go from here? Let us first consider the virus as a friend. In the field of medicine, as has already been suggested in the *British Medical Journal*, it may be possible in the future to vaccinate against all pathological viruses by the production of stable non-pathogenic variants. In the same way that vaccination with vaccinia virus protects against smallpox, so the non-pathogenic variants would protect against the pathogenic forms.

Geneticists may expect some advance in their search for the gene and its detailed structure. The genetic competence of the nucleic acids in tobacco mosaic virus has been demonstrated following the separation from and reconstitution with protein. Fractionation of the nucleic acids may well lead to some understanding of their biochemical relationships and function.

Another practical field in which "viruses made to order" would be of great value is the biological control of pests. A current example is the state of myxomatosis in Australia. After the war, following the years of labour shortage with consequent reduction in pest control, Australia was faced with the worst plague of rabbits in its history. The rabbit population was estimated to be over 300 million. The pasture consumption of rabbits is gauged, by comparative feeding trials, to be 6–8 rabbits to one sheep. Even if this is pessimistically speculative, rabbits were consuming a considerable portion of the country's potential grazing; they were out of control, and adversely affecting the economy. The release of myxomatosis (myxoma virus) in 1950–51 brought dramatic relief. The virus spread rapidly over Victoria, South Australia, New South Wales, and southern Queensland. Kills as high as 99·8% were estimated in many areas, and in many parts of the country it was difficult to find a rabbit. Within two years the appearance of attenuated strains of virus in the field was reported. By 1954, in spite of continued release of virulent virus by property owners, an attenuated strain KM13, was well established over most of the country. This strain had a case mortality of about 85%, allowing a high selection differential for genetic resistance. Evidence confirming the build-up of genetic resistance was carefully collected by Fenner and his associates as described by Sobey (1955).* The rabbit as a pest had been checked but not eliminated, and while the estimated annual benefits of £50 million to the country seem rosy, the future prospect of ever-increasing numbers of rabbits genetically resistant to myxomatosis is more than sobering. The solution to this problem would look less bleak if viruses could be manufactured with the killing properties, ease of dissemination, rabbit specificity of myxoma, and with a totally new serological specificity. With such viruses to hand the elimination of rabbits from the continent would become more of a possibility.

* Sobey, W. R., *J. Aust. Inst. agric. Sci.*, 1955, vol. 21, p. 135.

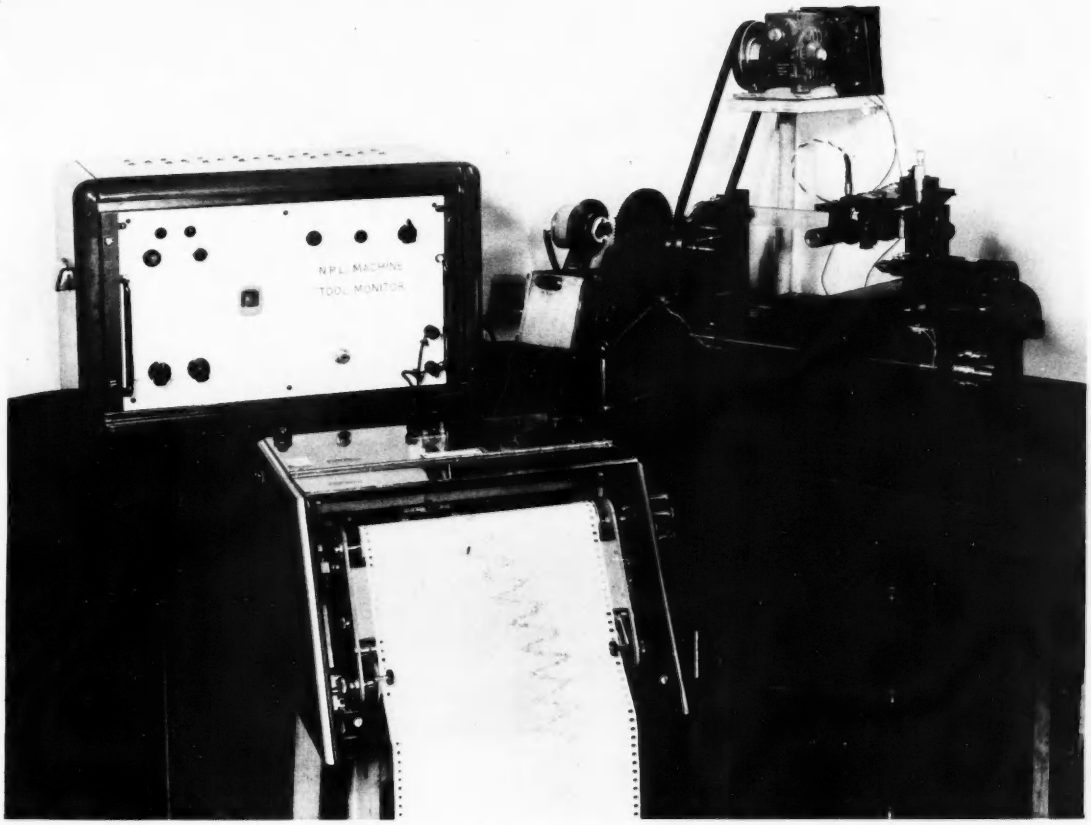
The virus as a foe is a formidable opponent. The use of manufactured viruses in germ warfare could well equal or exceed the horrors of atomic warfare. Imagine unfamiliar pathological viruses by contact or inhalation being delivered by missiles, or sprayed from the air in high concentration. Different viruses could be delivered every day by an enemy immunised against all of them. Science fiction today, but what odds tomorrow?

A CASE OF MECHANICAL EUGENICS

During its two annual Open Days, the National Physical Laboratory showed over 250 exhibits. Considered from the point of view of its future implications, probably the most significant item on display was a machine-tool monitor.

For some years now, the NPL has been making replica diffraction gratings with rulings spaced evenly to metrological standards, that is, to micro-inches. The machine-tool monitor on show used such gratings for the precise monitoring of a screw-cutting lathe. Even the best lathe with a corrector bar produces a screw-thread with a number of errors and, to measure and record these, the motion of the lathe saddle was compared with the rotation of the spindle. The moiré fringe technique, developed by the NPL and now used for the automatic control of machine-tools, was used to produce fringes from two identical gratings. One of these was a short one which moved with the saddle, and the other a long one fixed to the bed of the lathe. The moiré fringes were viewed by a phototransistor also moving with the saddle. As the fringes crossed the phototransistor, electrical pulses were produced, one pulse being equivalent to the saddle moving through one grating spacing. The lathe spindle was coupled to a potentiometer which produced a saw-tooth voltage with a frequency equal to the number of rotations per second of the spindle. The pulses from the phototransistor were arranged to sample this saw-tooth voltage. The apparatus on show was cutting a thread of the same pitch as the control grating; hence one sample voltage was produced every revolution of the spindle. If the lathe had been perfect, the amplitude of each sample would have been identical and the pen-recorder, which was being fed with the signals produced, would have drawn a straight line. But even the high-quality lathe on display (incidentally it was the lathe which cut the mandrels for the first Merton-NPL replica gratings) appeared highly inaccurate under this stringent test. The recordings showed slow periodic errors due to imperfections in the lead-screw with higher frequency components superimposed on them, these being caused by errors in the gear wheels forming the gear train between the spindle and the lead-screw. All these errors, of course, appear in the thread being cut. So sensitive was the apparatus that pressing one's finger against the saddle resulted in a significant swing of the recording pen, giving the impression that the lathe was made of a highly flexible material instead of steel.

Not only did this equipment continuously monitor and record the errors inherent in the lathe; it did it with

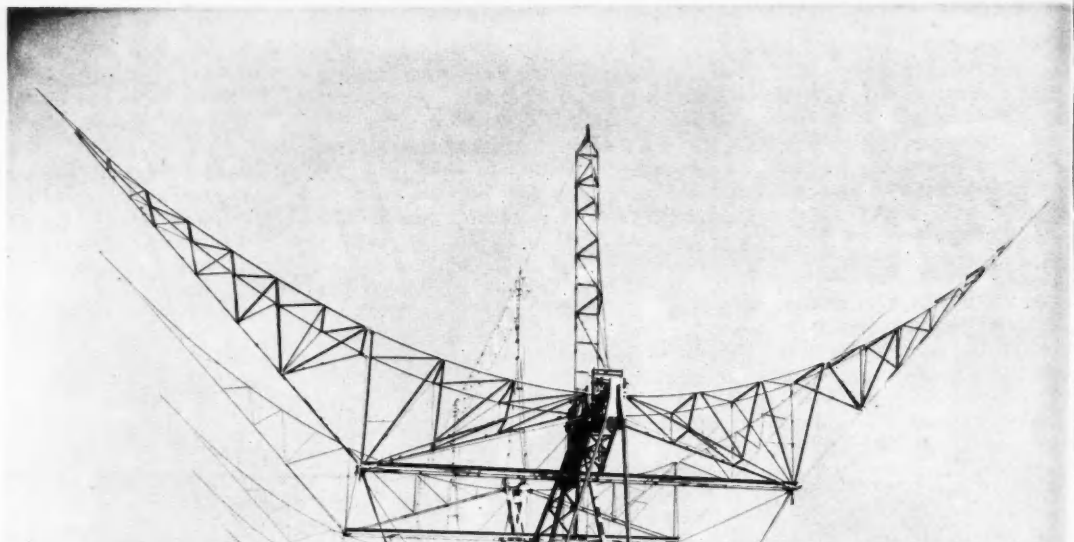


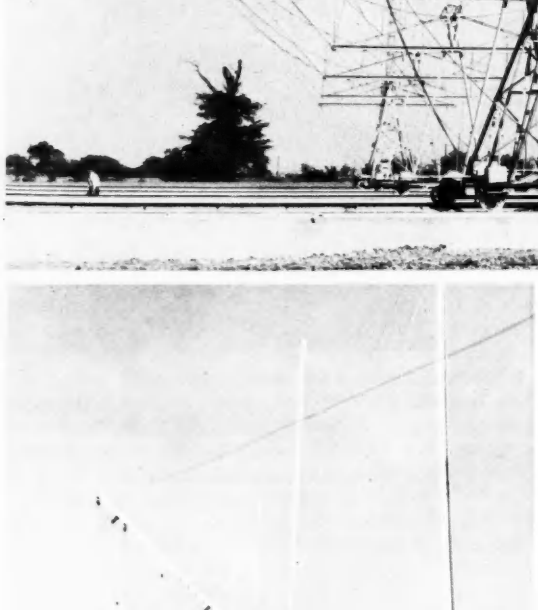
Machine-tool Monitor at the NPL, showing a screw-cutting lathe working under the control of a diffraction grating (under development).

an accuracy better than any previous screw-thread comparator. It appears, though, that this is but the beginning. The next step, already being taken, is to feed back the error signal and make it actually move the cutting tool relative to the saddle. In this way the inherent lathe errors could be eliminated *before the thread is cut*, and a screw-thread of hitherto unattainable accuracy should result. This might be the beginning of a breeding programme, because this highly accurate thread could be used as the lead-screw of another monitored lathe and so produce an even more accurate thread—a process of mechanical eugenics.

In case it should be thought that comparing a screw-thread against a diffraction grating which was itself produced by cutting a screw-thread is merely a case of going round in a metrological circle, it must be noted that the control grating is amenable to precise comparison with length standards to an accuracy at least one order of magnitude better than the finest screw-thread we can imagine. But even this apparent paradox will be eliminated when the NPL completes its present researches and produces diffraction gratings by photographing, on colloidal emulsions of extreme resolving power, closely spaced interference fringes. These will have many thousands of lines per inch with an accuracy of spacing dependent only on the perfection of a pair of optical flats.

This programme of research may well result in a new standard of accuracy in machine tools. It is appropriate that the NPL, the guardian of our standards, should thus maintain its tradition of raising the standards of accuracy of industry. It is the precision of our machine tools which dictates the quality of our production. Better tools lead to better products or even to products not yet possible because of the relative crudity of even the most refined manufacturing methods. If this latest work at the NPL fulfils its initial promise, it will be of philosophical interest that the entire precision of our mass-production may rest on the man who laps the optical flats used to produce the master-control grating. A craftsman using his hands can still make a flatter surface than any machine.





Above. The 190 feet long moving aerial at the Mullard Radio Astronomy Observatory of Cambridge University.

Left. The 3200 feet long fixed aerial.

MODERN STRING AND SEALING-WAX

At the end of July the Mullard Radio Astronomy Observatory of Cambridge University was opened by Sir Edward Appleton, F.R.S. The observatory is part of the Cavendish Laboratory, and is under the direction of Mr Martin Ryle, F.R.S. It continues the tradition of the Cavendish Laboratory, of achieving maximum results with the minimum of equipment. Miles of wire and Dexion slotted angle here replace the traditional "string and sealing-wax". Instead of the large movable parabolic dish at Jodrell Bank (DISCOVERY, August), the Cambridge Observatory relies on the interferometer and aperture synthesis principle. That is to say, one long stationary antenna and one small movable one achieve the same result as a large antenna, the size of the square of the stationary one. The results must be worked out by electronic computer.

TECHNOLOGY AND WORLD ADVANCEMENT

P. M. S. BLACKETT, F.R.S.

Presidential address at the Dublin Meeting of the British Association for the Advancement of Science

Scientists have often been reproached for not concerning themselves sufficiently with the effects—for good or ill—of their discoveries on society. This charge can hardly be laid against recent Presidents of the British Association. Most of my illustrious predecessors of the last decade have dealt in one way or another with the impact on contemporary society of the vast eruption of scientific and technological discovery, which is by far the most historically significant facet of our epoch.

Last year a special committee was appointed by Council to re-formulate the objectives of the Association in the light of present-day conditions—so different from those of 1831, the year of our founding. One of their recommendations was that still more stress should be laid on the social consequences of modern science and technology. I think that this advice is wise. However, I cannot deny that to follow it is to risk becoming controversial. I do not mean controversial over matters of scientific fact and theory, but controversial in a plain political sense.

For in science and technology lies the key to wealth; and the creation and distribution of wealth are the warp and woof of the many-patterned texture of politics. Many scientists and engineers—let us be quite frank about it—have in the past deliberately avoided thinking more than they can help about the social consequences of their collective achievements: just because, to do so, would sweep them into the troubled waters of political controversy. Some of our scientific predecessors were far less inhibited. It is worth recalling the forthright dictum in 1802 of the young Humphry Davy: "The unequal division of property and labour, the differences of rank and condition among mankind, are the sources of power in civilised life, its moving causes and even its very soul." Davy, who has been called the major prophet of the new class of applied scientist, had no scruples about expressing frankly his views on a major problem of his day. I will try to emulate his forthrightness in expressing my views on what seems to me to be the major and very different problem of ours.

It has often been held that the development of natural science and technology gives rise to political controversy only because of the backwardness of the social sciences. If the social consequences of technology, and indeed the problems of society in general, could be studied with the same objective impartiality which has worked such miracles in the physical world, then, so it is alleged, much of the sordid controversy of politics could be avoided.

This is less than half a truth. While all will echo Lord Adrian's plea at Oxford in 1954 for a more rapid development of the social sciences, one must be clear about their limitations. The facts discovered by social scientists—including economists—and the theories which they elaborate, cannot by themselves define the objectives of social policy: what the goals should be must ultimately rest on a judgment of value by individuals. Such judgments of priorities, when made by social groups, become political programmes.

When technological advance increases a nation's power to produce wealth, how should this be used? How much should be devoted to more material goods and how much to more personal leisure and to gracious living; how much to providing greater consumption now and how much should be set aside for the future; how much to greater opportunity for youth and how much to greater security or luxury for old age; how and to what extent should different kinds of ability and enterprise be rewarded? The social scientist can assist us to think rationally about such alternative uses for our material wealth and may help us to attain any end we choose; he cannot make the choice for us.

THE GAP IN WEALTH BETWEEN EAST AND WEST

Though few today in the rich Western world are naïve enough to think that an increase of material wealth necessarily results in a corresponding increase of human happiness and personal fulfilment, yet few would deny the validity of using a nation's material wealth as a measure of its potential welfare.

One of the most striking features of our contemporary world is the very uneven distribution of material wealth. Leaving aside the countries in the Soviet orbit, as needing separate discussion which will not be attempted, we have at the one extreme the highly industrialised countries of Europe and of North America and Australasia, with, in round figures, a population of 400 million, and an average income a head of £300 a year (at 1949 prices). For Europe alone the average is £200 a year. Within this group of relatively rich Western countries there is, of course, a wide range of average income, from one-third to more than double the average. Three hundred years ago, the pre-industrial countries of Europe had a real income a head of not much more than one-tenth of what it is today. In the last half-century their wealth has been increasing at a rough average of nearly 2% a head every year, thus doubling in rather less than forty years. This huge and historically rapid rise in individual wealth was accompanied by a very large rise in population.

In marked contrast to the rich West are the still pre-industrial countries, particularly those of Asia, Africa, and South America. These—excluding the Chinese Peoples' Republic—have a population of some 1000 million people and an average income of about £20 a year a head, that is, one-tenth that of Europe and a still smaller fraction of that of the West as a whole. Moreover, this low income does not on the average seem to

have increased much during the last three centuries and may at times have fallen, despite the revolutionary improvements in world technology as a whole during this period. It seems from such figures that 300 years ago the standard of life in at least the most advanced nations of the East, such as China, India, or Persia, must have been as high as that of Europe. The gap now of ten to one in favour of Europe is of quite recent origin and is due to the sudden advance of the West, mainly in the last 200 years, whereas the Eastern countries have remained nearly static.

Economists have recently been turning their attention to the complex historic causes which lead a country to transform itself from a static pre-industrial state to a growing industrial one. Making apt use of an aeronautical metaphor, the American economist Rostow has named this vital period of transition "the take-off into sustained growth". In Britain, the first country to become fully industrialised, this critical period seems to have been the last twenty years of the 18th century.

In a typical pre-industrial country, three-quarters or more of the population may be engaged in agriculture, and wealth tends to remain constant or rises but slowly. Savings and gross investment are low, some 5% or less of the national income, that is, only about enough to maintain a static economy by paying for the depreciation of existing wealth. After take-off, savings and gross investment rise till some 15% of the national income is available for gross investment, leaving around 10% for net new productive investment. On the average in the West today such new investment results in a rise of gross income of about 3% a year. Allowing for the population rise of some 1%, this gives an increase of wealth a head around 2% a year. The fraction of the population engaged in agriculture steadily falls as social development and industrialisation proceed, and agriculture itself becomes partly industrialised and so much more efficient. In Britain, the savings and investment required for the take-off were essentially provided by the prosperous classes who did not spend their surplus wealth on ostentatious living but invested it in productive industry. It is to this fact which Humphry Davy referred in the remark I have quoted.

Everyone recognises that most scientific and technological innovations can lead to continually increasing wealth only when they become embodied in material things, particularly production goods such as machine tools, chemical and fertiliser plants, transport, and communication systems. Nuclear power, the outstanding technical development of this decade, adds to wealth only when nuclear power stations have been built. However, the large amount of capital required is not always appreciated, especially by scientists and inventors, who naturally wish to see their discoveries and inventions used. For heavy basic industries such as steel, oil refining, or heavy chemicals, a capital of £5000 to £10,000 a man employed is required; for medium and light manufacturing industries perhaps from £1000 to £3000. Such sums must come from governmental, corporate, or personal savings, that is, at the expense of present consumption; or, alternatively, from external loans. The high capital cost of industrialisation is the main reason why the take-off is such a difficult operation for the pre-industrial countries. This is especially so at present because most production goods must be imported, thus making heavy demands on foreign exchange, which, except in a few oil- and mineral-producing countries, is chronically short.

In addition to maintaining its existing wealth, the Western world is saving and investing productively some 10% of its income of £300 a year a head; that is some £30 a year a head is being invested in additional plant and machinery to create more wealth. The pre-industrial countries of Asia only have about £20 a head to live on, that is, for both consumption and production goods. The West is thus saving more than the East is spending on everything. No wonder that the gap in wealth between the West and Asia is steadily widening. Moreover, most new scientific and technical discoveries or developments tend to widen the gap still more just because the already rich countries have the capital to make full use of them, but the poor countries have not. For instance, under present conditions, the advent of nuclear power must tend to widen the absolute gap still further, because of the high capital expenses of nuclear power stations. Decidedly, scientific and technical invention is no fairy wand to wave over a poor country to transform it into a rich one.

ASIAN COUNTRIES

Anyone who wishes to make himself familiar in detail with the degree of poverty of the under-developed countries of the world, particularly those of South-East Asia, India, Pakistan, Ceylon, Burma, Indo-China, and Indonesia, will find abundant material at his disposal. In recent years there has been a spate of blue books, white papers, newspaper leaders, speeches, tracts, and academic treatises, in which can be found statistics, eloquent writing, moral and political fervour. Of special importance were President Truman's "Point Four" in his inaugural speech in 1949, and the Colombo Plan in 1950.

When after the Second World War these countries threw off alien rule, the ills of South-East Asia—poverty, underfeeding, disease, and illiteracy—became important factors in international relations. These new independent countries became free to make their own external and foreign policy, based on their own views of their own interests. They can now choose for themselves with which countries they will trade or with which they will have close diplomatic or military relations. Moreover, no political party in these new Asian countries can hope to maintain itself long in power if it does not succeed in improving the lot of its people. The pre-industrial countries of the East can only become less poor by saving and investing money in better education, agriculture, social services, and industrialisation. If they are to do this out of their own resources alone, they must inevitably increase their poverty temporarily.

Several careful investigations have been made of the needs for external financial aid in the form of long-term loans and gifts to enable all these have-not countries

to make a good start on the road to prosperity. It seems that the *immediate* need is not far from the round figure of £1000 million a year, that is, £1 a year for each of the 1000 million inhabitants of these countries. It is difficult to ascertain the amount actually made available for other than defence purposes from the Western nations under the various aid schemes, such as the Colombo Plan, the Colonial Development projects, technical aid through the United Nations, and through various bilateral agreements. Though quite considerable, the amount is almost certainly only a fraction of the above requirement.

Since, of all the former dependent countries, India has the best worked-out plan of social advance and, moreover, is much the largest, it will be convenient to discuss her situation in some detail. Many of the problems facing India are common to other under-developed countries, whether in South-East Asia, Africa, or South America. The Planning Commission in New Delhi is aided by a powerful statistical and economic group in Calcutta, presided over by a mathematical statistician, Prof. Mahalanobis, Fellow of the Royal Society of London. This research group has been assisted by economists from both Western and Soviet countries in the study of the problem of how India can most easily, quickly, and painlessly emerge from the nearly static and essentially pre-industrial state in which she found herself on attaining independence in 1947.

During the period of the first Indian five-year plan ending in 1956, the national income rose by 18%. This is an important, even if precarious achievement, in marked contrast to the stagnation of the previous decades. In the second five-year period, 1956–61, a rise of national income of 25% is planned, that is, 5% a year. Whether India can achieve this without additional external financial aid is now doubtful, especially in view of her present large deficiency in her balance of payments. The plan involves not only attaining the high rate of new productive investment of at least 10% of the national income, but also an annual return of 50% in terms of additional output on the capital invested. Such a high net marginal return on capital can only result from very wise planning and efficient execution of the overall pattern of development. Allowing for the population rise of 1·3% a year, the planned rise of income a head is 5% minus 1·3% or 3·7% a year.

Such a rate of rise, *if achieved*, would be nearly twice the average of Western Europe at the present time. So the *relative gap*, that is, the ratio between the living standards of India and of Europe, would slowly begin to close. But how slowly! If these rates continued, nearly half a century would elapse before the living standard of India would climb from one-tenth to one-fifth of that of Europe. Moreover, the *actual* difference between the living standards, that is, the *absolute gap*, would still widen; for instance, if the assumed rates of advance are maintained for the next ten years, the *rise* of annual income of a European will be much more than the *final* income of an Indian.

The limit of India's possible rate of advance is set mainly by the available capital for productive investment, and particularly of foreign exchange to buy production goods from other countries. Failing massive external aid, the advance is limited to what a democratic parliamentary government of a very poor country can raise internally by taxation and loans.

It is clear that the population problem looms especially large to those who are pessimistic about the possibility of rapidly increasing material wealth, including food. Historically the population of Europe in the 19th century rose faster than that of Asia, but no population or food problem arose because wealth, including food, rose much faster. The population of the U.S.A. today is rising faster than that of India. As we have seen, the rise of population in such countries as those of South-East Asia does add, in a defined and calculable way, to the cost and burden of achieving economic progress. However, it is a not uncommon error among Westerners to assume implicitly that no marked economic and agricultural progress in these countries is possible, and so to be led to view them wearing social spectacles, through which little can be seen but millions of brown babies.

It is interesting to note that both the governments of India and of China have started to take steps to reduce the population rise. Success in these movements towards reducing the rate of rise of population can only be achieved by education, which itself depends on increasing wealth, and this can only come from industrialisation. Moreover, increasing industrialisation, as part of a general social advance, is the key to increased efficiency of agriculture and so to a greater food supply. Rural education, transport, power supplies, irrigation, agricultural machinery, fertilisers, pesticides, and improved seeds are the essential factors.

HISTORICAL ORIGINS OF SOCIAL DIFFERENCES

What is the historic origin of the astonishing differences today between the economic and social conditions of the West and East? A whole host of hypothetical causes have been advanced: differences in natural ability, climate, health, food, natural resources, religions, social systems, or methods of government. To attempt an answer to this problem, it is necessary to look deeply into history.

Archaeologists and historians have now made it possible to grasp the rough outlines of the history of technology. Since this word means "the science of the industrial arts", and since it is by these arts that the material goods of life are produced, the history of technology can almost be equated with the history of the material aspects of civilisation. With the recent publication of the first two volumes of the "History of Technology", with Charles Singer as editor-in-chief, the layman can easily survey in some detail, though with many gaps, the history of clothes, textiles, jewellery, cities, houses, temples, arms and armour, vehicles, domestic animals, crops, writing, sculpture, and pottery, from the emergence over 5000 years ago of civilised urban life in the river valleys of the Nile, Euphrates and Indus, up to the present day.

Abundant evidence proves the high level of technological achievement at a very early date. The astonishing building feats of the Egyptians and Mesopotamians are world-famous. Less widely known, are the gigantic town-planned cities of Northern India, such as Mohenjo Daro which flourished over 4000 years ago, with their main-drainage systems, vast granaries, and citizen's houses far better than those lived in by most Indians today. Innumerable examples abound in our museums or are illustrated in our histories, demonstrating the astonishing technical triumphs of antiquity. The stern beauty of the 4000-year-old bronze head of Sargon the Great, or the overpowering grandeur of the 3000-year-old inner coffin of Tutankhamen, alone suffice to prove that the highest artistry was allied to superb technical skill. The modernity in design of many articles of domestic use in ancient times is most striking. A wooden chair or a manicure set from the Egyptian New Kingdom of 1000 B.C. would not look out of place in the most up-to-date shop-window today, and might well be better made. A high level of domestic culture was by no means restricted to a few monarchs and officials. The cities of Crete, Babylonia, and Egypt around 2000 B.C. must have abounded in comfortable and cultivated people who led very pleasant lives, almost as refined and luxurious as prosperous people enjoy today. In the material arts of life one is constantly impressed by the absence of many major improvements between the height of the great Middle and Far Eastern Empires and the rise of modern technology in Europe about the 18th century A.D. Except for the last 200 years, Rudyard Kipling was not far wrong when he wrote:

> "We tell these tales, which are strictly true,
> Just by way of convincing you
> How very little, since things are made,
> Anything alters in any one's trade."

Slow and steady progress, of course, occurred in some fields, retrogression in others. Amongst the most important technological innovations since ancient times were firearms, the magnetic compass, printing with movable type, the horse collar, improvements in wind and water mills, and ocean-going ships. The first three were European medieval developments of much older Chinese discoveries, which had never before been exploited fully. They all predated the scientific revolution which only began around 1600 and thus belonged to the ancient craft tradition.

The contribution of China to the history of technology is only now beginning to be revealed, particularly by Joseph Needham and Wang Ling in "Science and Civilisation in China". Far Eastern technology appears to have been supreme between 500 B.C. and A.D. 1500. Belief in Europe of the technological superiority of the Far East was indeed widespread from Marco Polo in the 13th century to the French missionaries of the 18th. The wealth of the Indies was proverbial. Venice—"once did she hold the gorgeous East in fee"—grew rich by trading in textiles, spices, porcelain, and jewels.

During the first 200 years of modern science, from 1600 to 1800, science learnt much from technology, but taught it relatively little. The empirical industrial arts were already so highly developed, and indeed had been so for thousands of years, that systematic science had to develop far before it could improve decisively on pre-scientific technology. Even today, the biochemist cannot teach a chef how to cook a better omelette. Despite the interest of the Royal Society in the "useful arts", it was not until the last quarter of the 18th century that the impact of science on technology began to be decisively important.

The vast developments from the 17th century to the present day have been almost exclusively a Western achievement. Though the technological foundations on which Europe built arose mainly in the countries of the Near and Far East, these have hardly as yet shared in the later scientific and industrial revolution.

To the question why what happened did happen, I do not think there is an agreed answer. Certainly it had nothing to do with any inherent European superiority—indeed, the history of the previous millennia might well have suggested the opposite. Most probably it was differences in social and economic organisation which were the decisive factors.

Amongst the positive factors was certainly the growth after the 11th century of the city states of Italy, followed by the free cities of Northern Europe, where merchant entrepreneurs were free from many of the restrictions of feudal society. Not noble but not poor, these men, much like the Ionians of Thales' time 2000 years earlier, had a pecuniary interest in exploration and in technical innovation. This positive drive towards technological and social change in Europe might not have been sufficient to produce much more than a temporary spurt of pre-scientific technological advance had it not been for the scientific revolution which in the 17th and 18th centuries grew out of it.

An essential prerequisite for the scientific revolution was the weakening of the opposition of organised religion to the free play of scientific experimentation and speculation. As R. H. Tawney has shown, by the last half of the 17th century Europe was weary of a century and a half of religious strife. Religious tolerance first grew in the merchant cities, where it was found essential for trade. Intellectual tolerance followed in its wake. When the Civil War in Britain ended with the victory of the technologically progressive cities and merchant classes over the still feudally inclined monarchy and aristocracy, Britain was free from restrictions both on scientific thought and on the use of money for profitable and speculative investment. The way was clear for Britain to become the first industrial nation and to usher in our present scientific-technological age. However, even in these favourable circumstances the necessary conditions for the take-off did not exist till the end of the 18th century. The parliamentary system of government, which is Britain's proudest political achievement and still a major export, arose in mature form out of this long struggle against privilege and restriction.

One notices that the conquest of Asia and America by Europe was largely completed before the scientific

revolution. It was Western superiority in the pre-scientific technology of firearms and ocean-going ships which formed the material basis of the rise of the European empires in Asia and America. Europe was then passing through one of those periods of intense and ruthless energy, both mental and physical, which occur, for complex reasons, from time to time in the history of mankind.

Just when Europe was in a crusading, expansive, and aggressive mood, the once great Indian Mogul Empire began to disintegrate, as so many empires have done in the past. Portugal, Holland, France, and Britain fought long and bitterly for the spoils. Finally India, Burma, and Ceylon fell to Britain, Indonesia to Holland, and Indo-China to France, to be governed from Europe till they acquired their independence after the Second World War. China, though humiliated and partially occupied, never came completely under Western dominance. The vast Chinese Empire seems to have been too rigid to change of its own accord, but survived mainly because of the bitter rivalries between the Western Powers. Japan alone of Asian nations both accepted Western technology and avoided Western dominance. In fact, for a time she beat the West at her own game by achieving a more rapid rise in income than any West European country before or since, and reached a wealth a head at least as high as that of the poorer countries of Europe. This success had a profound effect on those Asian countries which were struggling at that time to be free from Western dominance.

The impact of the West on some of the static or declining pre-industrial civilisations of Asia brought about certain fundamental changes essential to social advancement, including the weakening of the power of the old feudal aristocracies, the growth of a merchant class, the introduction of Western education, science, and medicine, and in some cases the beginnings of a modern industrial and transport system. However, in no Asian country except Japan was the take-off achieved.

It is notoriously hard for Westerners to regard with detachment the long period of European ascendency in the East. With the fading of the ascendancy, objectivity is becoming easier, and the West has no longer any excuse for not appreciating the Asian viewpoint. The Indian scholar-diplomat K. M. Pannikar in his recent book "Asia and Western Dominance" tells the story of the relations between East and West from Vasco da Gama's landing at Calicut in 1498 to the present day. The reader who meditates on some aspects of the story will be inclined to adapt an old aphorism originally applied nearer home and say: "History is something that Europeans should remember and Asians should forget." In truth most Asians have, or politely pretend they have, and this is in no small part due to Britain's freeing of India, Pakistan, Ceylon, and Burma after the war: in my view, one of the greatest single acts of British statesmanship of this century. It is, I think, a tribute to both the Indian and the British peoples that after decades of bitter political struggle, personal relationships between Indian and British individuals are closer than ever before. It is important, however, to remember that most South and South-East Asian countries attribute much of their present backwardness to colonial rule. This was a constant theme at the recent conference at Bandoeng of the representatives of 1500 million coloured people.

ASSESSING HUMAN ATTRIBUTES

After 2000 years of relative stagnation of world technology, Europeans staged a scientific, technological, and industrial revolution, which has transformed within three centuries, and is still transforming, both the material way of life and the mental outlook of mankind. This astonishing achievement of the peoples of Europe must rank with the greatest events of world history. During the centuries when European scientists, technologists, and craftsmen were conquering nature, European fighting men, missionaries, traders, and administrators were conquering the world. By the close of the 19th century 100 million Europeans were ruling some 700 million people in Asia, Africa, and America.

Understandably, this double and interrelated triumph of the West over both nature and the world went to its head. By the last half of the 19th century the doctrine of the innate superiority of the white peoples, with its corollary of the inferiority and incapability of coloured people, had become widely accepted in the West. To a great extent, white racialism is economic and administrative in origin. Men tend to feel superior to those whom they rule and to despise those whom they exploit.

What has science to say of the innate mental differences between the different races of mankind? Rather little, it seems—at any rate so far. The physical differences of colour, features, and stature are obvious without the aid of scientific study. It may well be that innate differences of mental make-up do exist: but scientific study has failed as yet to establish their existence or nature. Moreover, even if mental and temperamental differences could be demonstrated as innate in such qualities as courage and determination of purpose, physical strength and skill, or in musical, literary, artistic, mathematical, and analytical power, between the individuals of different races, the attempt to rate different races in an acceptable general order of merit is foredoomed to failure. For no agreement would be obtainable on the relative weight to be attached to the various abilities: indeed, the various human qualities have different values in different environments.

Even if further studies should show marked differences now between different races, it would be as dangerous to extrapolate too far forward into the future just as the history of technology has shown it to be dangerous to extrapolate back into even the relatively recent past. The artistic and technical triumphs during the Middle Ages of Peru, Mexico, India, Indo-China, and China are a perpetual reminder that great creative ability and immense energy have appeared quite recently among many different peoples, with diverse social systems and religions, and vastly different climates. The grandeur of Cusco, Chichen-Itza, Fatehpur-sikri, Angkor Vat, and the Forbidden City in Peking are permanent memorials

of not very distant achievements of the coloured peoples of the world.

I am convinced that Western pessimism about the possibility of social advance by ex-colonial Asian countries is both unjustified in fact and a serious cause of practical error. It has led the West to over-estimate the need of the have-not countries for technical advice from Western experts and to under-estimate the need for simple financial help. Admirable as many of the schemes of technical aid have been, particularly those in education, medicine, and agriculture, the sending of experts to poor countries without the capital to carry out their plans, could be as irritating as to send a trained cook to a family unable to pay the baker. In so far as expert aid by Western technical personnel is needed by an under-developed country, it is usually both more efficient and cheaper to provide money for the country itself to hire those whom it needs. Unless followed up by massive financial help, some of the West's present aid programme may yet merit the war-time wisecrack of "offering all aid short of help".

What would constitute real help? The figures already given suggest that in addition to likely commercial and government short-term lending an additional £1000 million a year is needed as a free gift or as long-term loans from the 400 million rich Westerners to the 1000 million Asians, Africans, and South Americans in the under-developed countries outside the Soviet orbit. To the Western donors, this would amount to a levy of less than 1% of their income; Britain would pay £150 million a year, and this would only postpone by less than a year the expected rise of 50% in British living standards over the next quarter of a century.

To the recipient country, it would mean £1 a year a head in foreign exchange, that is, a 5% addition to their income of £20 a year. If wisely invested, this should allow the standard of life to rise at rather more than an extra 2% a year. It would therefore make an appreciable contribution to the oustanding problem of the now widening gap.

Such aid to a nation with a well-developed national plan would probably not be needed for more than a limited period, perhaps one or two decades. By then she should have achieved the take-off and be in a state of sustained economic growth, able to dispense with outside aid. Extending the aeronautical metaphor, the suggested Western action would amount to using its great wealth and material power to give the have-not countries an *assisted take-off*. It must always be remembered that without a strong and intelligently directed internal drive for social betterment, no country can achieve much. Outside aid can only help fully those who are already prepared to help themselves to the limit of their capacity.

Some may think I have taken a too severely economic attitude to the problem of the have-not countries and have neglected the more spiritual factors. Undoubtedly the citizens of a static pre-industrial country may possess many qualities such as contentment, humility, kindness, and gaiety in greater measure than those of a rich and progressive country. Though this is true, it is a doctrine which the restless and prodigal West might well preach to itself rather than to others. With nations, as with individuals, the ultimate hypocrisy of the rich is to preach the virtue of poverty to the poor.

REVERSE LEND-LEASE

The essential fact of the present-day non-Soviet world is that the huge gap of material living standards between the industrial and the pre-industrial countries is steadily widening. Moreover, most new technological advances tend to widen it still further. If present tendencies were to continue for many decades, then one would find many of the ex-colonial and similar countries still largely pre-industrial and so very poor. On the other hand, the vast acceleration of technological progress in the West will be leading the most advanced of the industrial countries to pass progressively, if they so wish, through the phase of the four-day week, on the road perhaps to the final bliss, or ultimate boredom—according to temperament—of the five-day week-end. The difference today in material wealth cannot be primarily attributed to differences of national or racial aptitudes, but has complex historical origins. Moreover, the gap in wealth is now so great that an important contribution to narrowing it could be achieved at a relatively small cost to the rich industrial countries.

In turning to consider whether the Western world should make this sacrifice, we leave the field of social analysis and enter that of political and moral controversy. Some people will stress the long-range political dangers of the widening gap and that the survival of parliamentary systems of government in many of the under-developed countries may be dependent on the achievement of rapid social progress. Others will lay most weight on military considerations, arising out of the polarisation of so much of the world into Soviet and anti-Soviet blocs. If the West does not help, perhaps the Soviet bloc will. This has hitherto been by far the strongest stimulus to what Western aid has been forthcoming. Strong economic arguments can be produced: poor countries are also poor markets for manufactured goods, and may be unreliable suppliers of essential raw materials: such "enlightened self-interest" is particularly relevant for Britain with her essential dependence on overseas trade. Some of the strongest motives for a substantial aid programme arise from moral and religious values. Many feel that such large differences of wealth, health, and opportunity are wrong, and that to work to reduce them would give a new sense of moral purpose to the West. Recently Ritchie Calder has aptly suggested that massive Western aid to Asia might be considered as reverse lend-lease for the incalculable debt which the West owes to the East for the age-old gift of the great tradition of empirical technology which was the essential first basis of Western triumphs. One might add—for it is often forgotten—that all the great religions of the world are of Asian origin.

Here are motives enough for each of us to weigh and make his choice. My own view is clear. I think the West should make the great experiment of sacrificing some of its immediate prosperity to give massive aid to

the have-not countries. To give this aid would not, I believe, prove very painful and it may do us a power of immediate moral good and, ultimately, of material good as well. If the major nations of the West cannot agree quickly to provide the required £1000 million, then I would hope that Britain would "go it alone" and make her contribution of £150 million a year available to her former colonies, in addition to what she is already doing. In holding this view, I do not forget the many economic and social problems nearer home which need urgent attention.

Scientists and technologists have a special responsibility in this matter, since it is their genius and their skill which alone can bring the material basis of happiness within the reach of all. The progress of the natural sciences, the West's greatest achievement, has been based on experiment. Let us make now this great social experiment to spread the benefits of our labours. At present they reach only a few. A have-not country, bound like a modern Tantalus by the chains of its lack of capital, gazes with unquenchable thirst on the growing riches of modern technology which it cannot enjoy.

Times and problems have changed since Humphry Davy commented so shrewdly on the social state of Britain at the very start of the industrial revolution. I will end this lay sermon—for this is what this address has become—by attempting to transmute his words to suit the contemporary scene:

The uneven division of power and wealth, the wide differences of health and comfort among the nations of mankind, are the sources of discord in the modern world, its major challenge and, unrelieved, its moral doom.

As is customary at the British Association Meeting, the Address by the President is given at a formal meeting on the first day. This year's Address was delivered on the evening of Wednesday, September 4. The publication of this issue of DISCOVERY *had therefore to be delayed until after the delivery of the Address, and so the publication date is September 5, 1957.*

TECHNIQUES AND PROBLEMS OF REACTOR RADIATION CHEMISTRY

A. R. ANDERSON AND J. K. LINACRE

Atomic Energy Research Establishment, Harwell

Radiation chemistry is the study of chemical effects produced by high-energy radiation and must be distinguished from radiochemistry, which concerns the chemical behaviour of radioactive species. High-energy radiations produce ionisations and excitations in the material through which they pass, leading to the formation of chemically active species which are responsible for the chemical effects observed. High-energy radiation is divided into two classes: "densely ionising" radiations such as alpha particles and recoil ions from fast neutron bombardment, and "lightly ionising" radiations such as beta rays and gamma rays. This distinction is made because they differ in the number of ionisations and excitations produced per unit path length in the material through which they travel.

The intense radiation in a nuclear reactor increases the rates of many chemical reactions and induces other chemical effects which are unique to high-energy radiation. In order to understand and to assess the significance of these chemical effects, which often constitute problems in reactor design, the behaviour of the relevant chemical systems is studied under reactor radiation. The techniques which are used for this work in the Harwell reactor BEPO, together with some of the chemical problems which have been studied, are described.

NUCLEAR REACTORS

For the production of chemical effects a nuclear reactor could be regarded simply as a large source of high-energy radiation. This limited outlook is inadequate, however, as the chemist must acquire some elementary knowledge of nuclear physics and of reactor design to plan and interpret his experiments successfully.

A typical thermal nuclear reactor is a system in which the fission of uranium (U235) atoms can be maintained and controlled. In the nuclear fission process a uranium atom is split into two fragments by the interaction of a low-energy (slow) neutron, with the subsequent emission of two or three high-energy (fast) neutrons. These fast neutrons from the fission reaction are slowed down by repeated collisions with the atoms of a "moderator" so that some of them can interact with further uranium atoms and thus sustain a chain reaction. To remove the large amounts of heat produced during nuclear fission, and thus prevent the uranium from melting, the reacting system is cooled by a flow of gas or liquid.

In the Harwell reactor BEPO (Fig. 1), which is air-cooled (5), the reactor core (1) comprises uranium fuel rods, suitably contained in thin metal sheaths, dispersed throughout the graphite moderator (2) in a regular pattern. To minimise neutron escape from the core, no uranium rods are placed in the outer graphite blocks, so these act as neutron reflectors to return a large percentage of the escaping neutrons into the core. The fission chain reaction is controlled by movable hollow steel rods filled with boron carbide (3), which readily absorb slow neutrons and can, by their position in the reactor, regulate the number of slow neutrons which are available for the fission of uranium atoms. In order to provide regions of the reactor in which all the neutrons have low energies (so-called "thermal" neutrons), thermal columns (8), comprising simply stacks of graphite, are

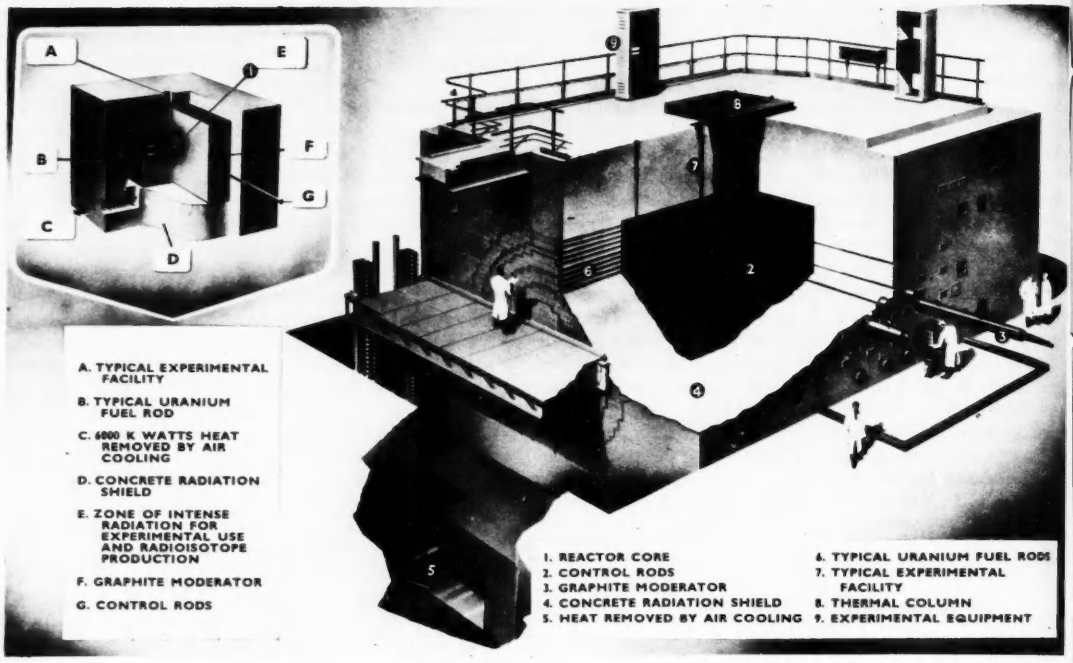


FIG. 1. Sectional view of BEPO.

built out from the core. The whole reactor is surrounded by a thick concrete shield (4) to protect personnel from the harmful radiation. Experimental holes (7), penetrating into various regions of the reactor, provide facilities in which experimental apparatus can be irradiated for any desired time. Each of these holes is provided with a close-fitting steel plug to prevent the escape of radiation when the reactor is operating.

In other reactors heavy water or ordinary water are used as moderator materials and heavy water or beryllium as neutron reflectors.

REACTOR RADIATION

The radiation in the core of a nuclear reactor comprises neutrons of various energies with the accompanying gamma rays produced during fission of uranium, by the decay of radioactive fission products, that is, the two particles which are formed when a uranium atom is split, and by neutron capture in the reactor materials. As these radiations are respectively "densely ionising" and "lightly ionising" in character, the extent of any chemical change produced by each may differ considerably. The chemical effects produced by these two classes of radiation, while qualitatively similar, often differ quantitatively; for example, the radiation-induced decomposition of pure water is much more extensive with densely ionising radiation than with lightly ionising radiation. Thus the extent of any chemical change induced by radiation in the core of a reactor will usually be different from that in the thermal column where the radiation comprises gamma rays and slow neutrons only. The latter have generally little effect on a chemical system. In consequence of the type and mixture of high-energy radiations in a nuclear reactor, it is important to study any radiation chemical problem of reactor design under irradiation conditions which will approximate as closely as possible to those in the proposed reactor. The use of different moderating materials results in varying proportions of densely ionising and lightly ionising radiation in different reactors.

The main disadvantages in the use of a nuclear reactor as a radiation source are the designing of equipment to fit the geometry of the experimental holes, the inaccessibility of experimental equipment for maintenance, and the radioactivities developed in materials by neutron absorption. A big advantage, however, is that the volume available for irradiations is large compared with other radiation sources of comparable intensity; for example, electrical machines such as the Van de Graaff generator and the linear accelerator.

TYPES OF CHEMICAL PROBLEMS IN REACTOR DESIGN

In general there are two types of problem with which the radiation chemist is concerned in reactor design. The more important type involves the chemical behaviour of the main reactor components—fuel, moderator, coolant, constructional materials—and their compatibility under irradiation, while the other type of problem is concerned with the effect of radiation on minor components involved in reactor design, such as lubricants and insulators. The number and classes of chemical sub-

stances which come within the latter category are so large that in general it is only possible to carry out empirical tests under specified irradiation conditions. In some cases, however, results of a wider and more fundamental nature have been obtained from early empirical tests.

While most chemical investigations in a reactor are directly concerned with the solution of a particular problem in reactor design, work of a more academic nature is also carried out. In this connexion the high intensity of mixed densely ionising and lightly ionising radiations in a nuclear reactor is of great interest.

EXPERIMENTAL TECHNIQUES

Chemical changes produced by high-energy radiations are estimated by fairly conventional methods of chemical analysis or physico-chemical examination, the measurements being made on the material after irradiation or on representative samples of the material withdrawn during irradiation. The chief experimental difficulties in reactor radiation chemistry are associated with the design of equipment to be placed in the reactor and the handling of radioactive material and equipment after irradiation.

All equipment to be placed in the reactor must be designed to fit one of the vertical or horizontal experimental holes in BEPO. This imposes severe geometrical limitations on the design, as these holes are long and of small cross-section: the vertical holes are generally about twenty feet long and four inches in diameter. The constructional materials for equipment designed to fit these experimental holes are specially chosen so that the absorption of thermal neutrons (resulting in fewer being available for uranium fission) and the radioactivities produced are minimised. For chemical work, fused silica is used in place of Pyrex glass, the high boron and sodium content of the latter being objectionable since boron readily absorbs thermal neutrons and sodium becomes highly radioactive. Aluminium is used wherever possible for metal parts of equipment, as its capacity to absorb thermal neutrons is low and radioactive species formed during irradiation are short-lived, enabling the equipment to be handled fairly quickly after irradiation.

After equipment has been removed from the reactor, some time must be allowed to elapse for the radioactivity to decay to a safe working-level; the time being determined by the material used, the length of the irradiation, and the intensity of the neutron radiation. Small equipment may be adequately shielded by placing it in thick-walled lead boxes while large pieces of equipment removed from BEPO are lowered into holes in the floor of the reactor hall (Fig. 2). Apparatus is designed so that it may be dismantled quickly and the essential parts easily removed, thus reducing the delay between irradiation and examination. If the radioactivity level of the material removed is still high it is necessary to carry out analysis and investigation behind adequate lead shielding employing remote manipulation of equipment. This work is done in laboratories specially designed for the safe handling of radioactive materials.

IRRADIATION TECHNIQUES

As pointed out previously, BEPO contains a very large number of experimental holes, enabling equipment to be placed in a radiation field of any intensity within the range obtainable in the reactor. Further, there are two thermal columns in the reactor, in which the radiation field is very different from that in the core, comprising gamma rays and slow neutrons only. The experimenter is, however, not limited to the use of the radiation fields naturally available in the reactor, but, by utilising certain nuclear reactions, can induce differing local radiation conditions in and around an experimental assembly. The proportion of fast neutrons may be increased by working inside a hollow uranium cylinder placed in the reactor, since there is no moderator present to slow down the neutrons formed in fission reactions in the uranium. The uranium is canned in a similar manner to fuel rods, and the assembly is usually water-cooled. The space available within such a cylinder is small and consequently little material may be irradiated at any one time.

The radiation field within an experimental assembly may be radically altered by the addition of some species which undergoes a nuclear reaction with the emission of some other radiation. Such a species is boron, which reacts with thermal neutrons to give energetic alpha and lithium particles

$$B^{10} + n \rightarrow Li^{7} + \alpha.$$

Investigations of reactions in aqueous solutions containing small amounts of boric acid have been made, reactions occurring being then due not only to the reactor radiation but also to the particle radiation from the solution itself. Boric-acid concentrations may be chosen so that the energy from alpha particle radiation greatly exceeds that due to the reactor radiation.

IRRADIATIONS WITH SUBSEQUENT EXAMINATION

The simplest type of experiment which can be carried out is an irradiation of material at reactor temperature for various periods of time, with subsequent examination on removal. Samples may be placed in an experimental hole when the reactor is shut down, and removed at the next appropriate shut-down. If it is desired to carry out short irradiations, however, some device must be employed which enables samples to be placed in and removed from the reactor while it is operating. Important among the latter are pneumatically operated high-speed "rabbit" devices. The rabbit, a special carrier which will contain small samples up to three inches in length and approximately one inch in diameter, is placed in a flight tube in which it is driven by compressed air, the apparatus being similar to the department-store change-carriers. Since the carriers are of small diameter, they may be passed into the reactor through a spiralled hole, which prevents the escape of radiation, and consequently may be used while the reactor is operating. These devices are particularly useful for carrying out short irradiations, of the order of minutes, since the transit times in the reactor, to and from the irradiation position, are so short.

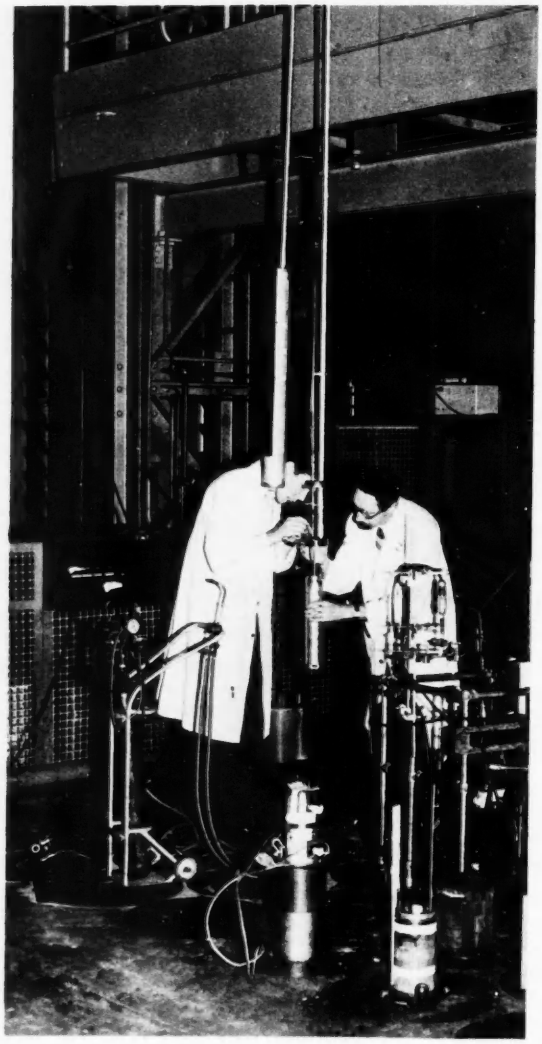


FIG. 2. Assembly of experimental equipment for irradiation in BEPO. The operators are attaching a furnace to the bottom of an aluminium support rod. Electrical leads and silica tubes coming from the furnace are fixed by aluminium clips to the support rod. In the foreground are shield plugs of experimental equipment which have been removed from the reactor and stored in deep holes in the floor.

Experiments of this type have been extensively used in carrying out tests of reactor component materials and in some more academic radiation chemical studies of reactions in solution. If the material under irradiation is solid, it may be placed in some container having a loosely fitting cap, provided no objectional gases are formed during irradiation. Numerous plastics have been irradiated in this manner, to investigate the decomposition and cross-linking phenomena which occur under reactor radiation. Polythene, for example, undergoes cross-linking which considerably increases the softening point of the irradiated material.

If liquids or gases are to be irradiated, they are usually contained in ampoules of fused silica, which are packed in aluminium containers for irradiation in the reactor, to prevent damage during handling. Care must be taken to ensure that the ampoules do not burst due to increase in pressure arising from evolution of gas during irradiation or increase in temperature. Investigations of reactions in water and aqueous solutions, and studies of gas reactions, such as the formation and decomposition of ammonia, have been carried out using this technique. An interesting study is that of the formation of nitric acid in solution on irradiation of a heterogeneous system of air or nitrogen and water. It is found here that the rate of acid formation is not controlled by a reaction in solution, but by some process in the gas phase. This reaction is of importance in reactors moderated with water if there is a gas space above the water in the core. Leakage of air into this gas space leads to acid conditions in the water, and hence increased rates of corrosion, unless some purification unit, such as an ion exchange bed, is included in the water circuit.

CONTINUOUS MEASUREMENT EXPERIMENTS

It is essential that reactor constructional materials should undergo little change under radiation and the extent of reaction between differing materials should be small. Nevertheless, the reactions which do occur may cause significant changes in the lifetime of a reactor, and they must be investigated. Preliminary investigations are frequently carried out in silica experimental equipment designed to be placed in an experimental hole, and in order to follow the course of a reaction it is often desirable to analyse representative samples removed at various times. Experiments of this nature are designed to be as flexible as possible, and it is usual to attempt to investigate a large range of experimental conditions and to design the equipment accordingly. This type of investigation is best illustrated by reference to the study of the reaction between graphite and carbon dioxide, made in connexion with development of the Calder Hall reactors, in which carbon dioxide is used as a coolant and graphite as the moderator.

The apparatus employed was placed in a vertical experimental hole; assembly of equipment of this type is shown in Fig. 2. The reaction vessel containing a graphite sample was placed in a furnace which could be operated at controlled temperatures, these units being mounted on a support-rod attached to the shielding-plug. Electrical leads to the furnace, thermocouples, and fused silica leads to the reaction vessel were supported on the rod, and passed through holes in the shielding-plug. Flexible leads were passed through spiralled holes and glass leads through small-diameter straight holes, this giving the best possible shielding, as there is no escape of radiation through spiralled holes and little through small holes in the long plugs used. The complete apparatus was placed in an aluminium sheath for

FIG. 3. Removal of experimental equipment from BEPO. The operators are checking the radioactivity of equipment, protected by an aluminium sheath, after removal from the reactor. Near the feet of the operators are the slightly raised metal covers protecting silica leads from equipment in experimental holes. Behind the operators, around the edge of the reactor, is control and measuring equipment for experiments being conducted in the various experimental holes.

protection. The all-glass magnetically operated pump used to circulate the gas over the graphite sample, and the apparatus used for sampling and analysis of the gas were constructed on top of the reactor. Silica and electrical leads to the equipment in the experimental holes were covered by steel channelling across the floor on top of the reactor to prevent damage. Fig. 3 shows these features in a general view of the top of BEPO.

In this apparatus the temperature of the reaction vessel, the pressure and composition of the circulating gas and its flow rate across the sample could all be varied. Analyses carried out over a period of weeks followed the change in the carbon monoxide concentration of the circulating gas, from which the extent of reaction was deduced. It was found that a forward and back reaction occurred, leading to a stationary concentration of carbon monoxide and that the rates of reaction under radiation, though much higher than those of the thermal reactions alone, were yet acceptably small.

Apparatus similar to that described has been used to investigate reactions between graphite and other gases. The technique of irradiation with continuous measurement has been employed in the study of the decomposition of nitrate crystals under irradiation, the gases evolved being removed, measured, and analysed. Escape of rare gas fission products from irradiated uranium is investigated in a similar manner.

LOOP EXPERIMENTS

After preliminary investigations of the type described above have been carried out, it is usual to perform prolonged tests under conditions which simulate more closely those to be encountered in the proposed reactor design. For this purpose large test loops are constructed in which chemical, metallurgical, and engineering studies are carried out simultaneously. The simpler types of loops are often only a more elaborate version of the silica experimental equipment used for preliminary studies, having a test section in the reactor through which the coolant or liquid moderator under investigation is circulated, and associated external equipment. More complicated loop designs seek to simulate anticipated reactor conditions much more closely. In these, the test section in the reactor usually contains suitably

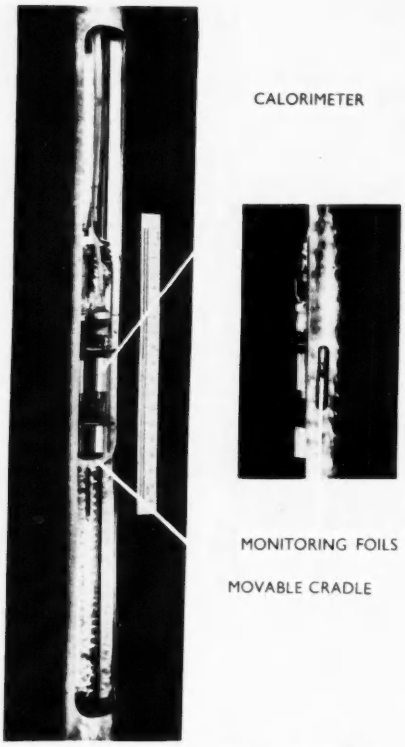


FIG. 4. Calorimeter for measuring energy absorption from reactor radiation.

canned uranium fuel and is designed to simulate closely an average fuel channel of the proposed reactor. Thus the test section should ideally be a channel through the core of the research reactor. This type of equipment may again be illustrated with respect to the graphite-CO_2 reaction, and the "Pippa Channel" loop constructed in BEPO to study it. Uranium fuel is placed in the channel, which is lined with annular graphite blocks, and carbon dioxide is circulated through the channel as coolant. The chemical reactions between graphite and carbon dioxide are followed by analysis of samples of the circulating gas and by periodic weighing of removable samples of graphite mounted in the lining of the channel. Metal specimens are also placed in the system, both within the reactor and in the external circuit, to study reactions between CO_2 and metals and to look for deposits of carbon. In designing this experiment factors of importance which were taken into consideration were the variation of heat and radiation intensities in the channel, the flow rate of the carbon dioxide coolant, the volume ratios of carbon dioxide and graphite in the reactor, the surface area of the graphite, and the ratio of the volumes of the system within the reactor and in the external circuit. Temperatures and radiation intensities may be adjusted by varying the percentage of the fissionable isotope U235 in the uranium fuel employed, while the other parameters are designed as closely as possible to those in the proposed reactor.

It is apparent that systems of such complexity as this can seldom operate over a wide range of conditions, and, being designed to do certain specific things, they tend to be experimentally inflexible. This type of experiment is, however, becoming increasingly important as new types of reactor are developed, and loops testing reactions of graphite with gases, and the use of high-temperature water, liquid metals, and certain organic compounds as reactor coolants and/or moderators are either in operation or proposed at Harwell.

QUANTITATIVE INTERPRETATION OF RADIATION EFFECTS IN A REACTOR

The extent of any radiation-induced change is dependent on the amount of energy which is absorbed by the system. In order to understand the quantitative interpretation of radiation effects, the ways in which energy is absorbed from reactor radiation are briefly considered. In a nuclear reaction radiation energy can be absorbed: (1) by the elastic scattering of fast neutrons (this mechanism is most important for elements of low atomic number, such as hydrogen and deuterium); (2) by the absorption of gamma radiation, a process important for all materials; (3) by nuclear reactions occurring in the material under irradiation. These reactions are quite specific and are usually induced by the absorption of thermal neutrons. A familiar but extreme example is the fission of uranium.

Because the radiation intensity varies in different parts of any reactor and from reactor to reactor, it is necessary to have some means of assessing the energy absorbed and thus interpreting the results quantitatively. This is extremely important when the results obtained in one reactor are to be applied to the design of a new reactor with a different moderator and dissimilar geometry. The amount of energy absorbed is called "radiation dose" and is not easy to measure in a reactor, which is a source of mixed densely ionising and lightly ionising radiations. This is because the response of instruments designed to measure the energy absorbed from, say, densely ionising radiations can be markedly affected by the presence of lightly ionising radiations and vice versa.

A simple, but approximate, method of estimating radiation dose is to integrate the reactor power level (approx. 6 megawatts in BEPO) with the period of irradiation; a unit of dose usually expressed in megawatt hours. It takes no account of possible variations in radiation intensity or in quality with position in the reactor, but is usually acceptable only as a comparative measure when the system under irradiation is so complex, as, for example, in a model channel experiment, that other methods of measuring the radiation dose are virtually impossible.

Perhaps the most widespread method for comparing the results of radiation-induced effects in nuclear reactors is the use of thermal neutron dose, that is, the integrated number of thermal neutrons which are incident on unit area of the sample during irradiation. This

is easily measured by determining the amount of radioactivity produced in a thin foil of suitable material, such as gold or cobalt, which is irradiated together with the material being studied. On exposure to reactor radiation, these materials absorb thermal neutrons to form radioactive isotopes. The beta or gamma radiation from these isotopes can be measured quantitatively so that the thermal neutron dose received by the material can be calculated. Unfortunately the use of thermal neutron dose alone is inadequate for quantitative radiation chemistry, since this method measures a component of reactor radiation which does not contribute to energy absorption apart from the initiation of specific nuclear reactions. This unit of dose can be related directly to chemical effects only if the principal energy-contributing components of reactor radiation—that is, fast neutrons and gamma radiation—are related unambiguously to thermal neutron intensity. This is not so for different reactors with unlike moderators and dissimilar geometry, nor is it necessarily true for different positions in the same reactor; for instance, the relationship is markedly different in the core and thermal column of BEPO.

In consequence, the only satisfactory basis for quantitative reactor radiation chemistry is a direct measurement of the energy absorbed by various materials in different positions in any reactor. These values of energy-absorption for a particular material can then be related to thermal neutron dose for the particular position and reactor in which the measurement has been made. In order to make these measurements of energy-absorption, a special calorimeter has been designed and developed at Harwell. By making measurements with various materials in BEPO, it has been possible to determine the amount of energy absorbed due to each of the three processes above.

Fig. 4 shows the calorimeter in a cut-away section of the equipment used to introduce it into a vertical experimental hole in BEPO. The calorimeter is mounted in a cradle which can be moved within the experimental hole, thus allowing measurements to be made in a large number of positions. The inset of Fig. 4 shows the monitoring foils which accompany each measurement so that the relationship between energy-absorption and thermal neutron dose can be established.

CONCLUSION

The rapid developments which are occurring in nuclear reactor design bring with them new problems in radiation chemistry as in engineering, metallurgy, and physics. To solve these problems in reactors with increasing radiation intensities, new experimental techniques have to be sought and developed. Already at Harwell the experience which has been gained in BEPO is being applied to the problems of irradiation techniques presented by the new heavy-water moderated reactor, DIDO, which is now operating.

PLASTICS EXHIBITION

The British Plastics Exhibition, which this year became international, emphasised the enormous range of potentialities of plastic materials, with their adaptation for use in ever-increasing spheres of industry. Most dramatic, perhaps, has been the perfecting and wide use of the electronic radiation process to give plastic materials new and previously unattained properties of resistance to heat, abrasion, and acids; and also the extended use of plastics reinforced with glass fibres usually in the form of chopped strand or woven matting.

The application of new methods in further fields of industry brings more scope for design and ingenuity. It also frequently gives rise to problems which need the assistance of outside, specialist bodies. The National Research Development Corporation displayed at the exhibition a device for measurement of thickness to facilitate the production of sheet material. Developed by the National Physical Laboratory, this equipment is designed for the continuous measurement, during production, of the thickness of thin, soft sheet material, such as cellulose acetate film. The sheet is passed over a precision ground roller which provides a datum for the measurement, and the thickness of the material is determined at sixteen points across its width by air jets blowing against its upper surface. The thickness of the sheet controls the flow of air from the jets, which in turn controls the pressures in the jet circuits. These pressures are interpreted and displayed as a measurement of sheet thickness according to conventional pneumatic gauging practice. In order to eliminate any significant error due to eccentric rotation of the roller, the jets are mounted in a floating beam which bears directly on the surface of the roller at its ends. The bearing-points take the form of pads faced with polytetrafluorethylene to minimise friction and wear. Provision for the insertion of precision packing pieces at the bearing-points enables the absolute thickness of the sheet to be determined by a substitution method.

There are two methods of displaying the thickness measurements. The thickness at all the measuring stations is indicated simultaneously by the liquid levels in a bank of manometers, one of which is connected to each jet circuit. The manometers are so arranged that the liquid levels give a direct display of the instantaneous thickness profile across the width of the sheet. At the same time, by means of a rotary selector switch, any one jet circuit may be connected through a pneumatic amplifier to a pen recorder, which provides a continuous chart record of the thickness at that particular station. Simple pneumatic devices are incorporated to facilitate the setting and operation of the equipment. In this way the problem of a small part of production is solved by the construction of a device which can be widely beneficial, and which serves to emphasise once more the link between research and industry.

DEEP OCEAN CURRENTS

G. E. R. DEACON, F.R.S.

Director, National Institute of Oceanography, Wormley, Surrey

Sailors and ocean travellers have always been interested in ocean currents and have profited by studying them. This was specially true a hundred years ago when the new charts of wind and current were helping to halve the time of many ocean passages. Today, although the charts are kept up to date by the Marine Division of the Meteorological Office and parallel authorities in other countries, the rewards are less spectacular. Some advance might be made if the day-to-day changes in the currents about the average speeds and directions shown on the charts could be reliably predicted. A modern ship is not affected by currents as much as an aeroplane is by winds, so that day-to-day forecasts of current cannot be as important as hour-to-hour forecasts of winds, but already one or two firms in the U.S.A. are making a living by providing forecasts of waves and currents, and the ships they advise save a tide or two.

Fishermen are more likely to take an interest in better knowledge of day-to-day changes in currents and closer understanding of the factors that influence water movements. The set of the current is likely to influence the movements of the fish and the shape and run of the nets, and more detailed understanding of the relations between wind, climate, and currents will help to explain changes on fishing-grounds and to show where to look for new ones. The oceans are not full of exploitable fish, and yet a number of profitable fisheries are being developed in the open ocean, far from the usual shallow grounds. They generally occur where the physical processes associated with current boundaries and changes in speed and direction cause upwelling of cold nutrient-rich water from the depths of the ocean up to the well-illuminated surface layer. Such fertile regions are best known where continental slopes and islands influence the currents, but they also occur in the deep ocean, where marine physics will be as safe a guide to profitable fisheries as a knowledge of the banks and shoals is in shallow water.

Another good reason for improving our knowledge of the circulation of the water in the oceans is being forced on us by problems which begin to arise in the disposal of industrial and atomic waste.

Although many sailors will still feel that the excellent charts of the average speed and direction of ocean currents based on the observations of the past hundred years are as much as we can hope for, and will reaffirm that experience at sea will be more useful than anything a scientist can do, there is a fairly clear indication that good use can be made of reliable day-to-day estimates of the speeds and directions of currents from the wind conditions prevailing at the time and other factors. To gain such a detailed understanding is much more difficult than the current charting done so far: no amount of ordinary sea-going observations and experience will allow precise assessments of the effect of the stress of the wind at the sea surface, the frictional drag at the bottom, the rotation of the Earth, and the stratification of the ocean. New recordings must be made, in the deep layers as well as at the surface, and they must be backed by theoretical work of a necessarily complex nature.

There are now a dozen or more young men, most of them trained in schools of dynamical meteorology, who are interested in the problem. Lack of knowledge of the deep-water movements is one of the main hindrances, and the most significant U.K. contribution has been the development, at the National Institute of Oceanography, of a new technique for measuring them. Having made sure that recordings of non-tidal flow cannot be made satisfactorily with current-meters suspended from ships moored by necessarily very long wires in deep water, an attempt was made to copy the radio-sonde technique used by meteorologists, using acoustic instead of radio signals, sent out by a buoy which sank slowly to the bottom of the sea instead of a balloon which climbs steadily into the sky. The first attempt was made with a light acoustic transmitter sinking below a string of poly-

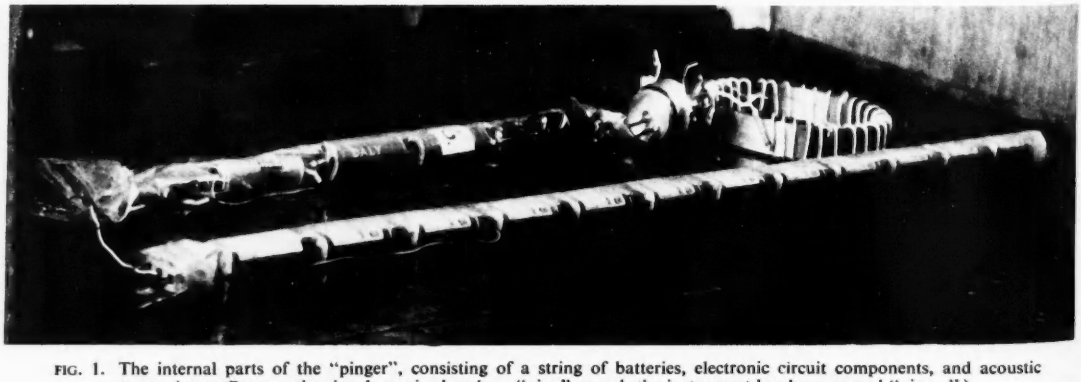
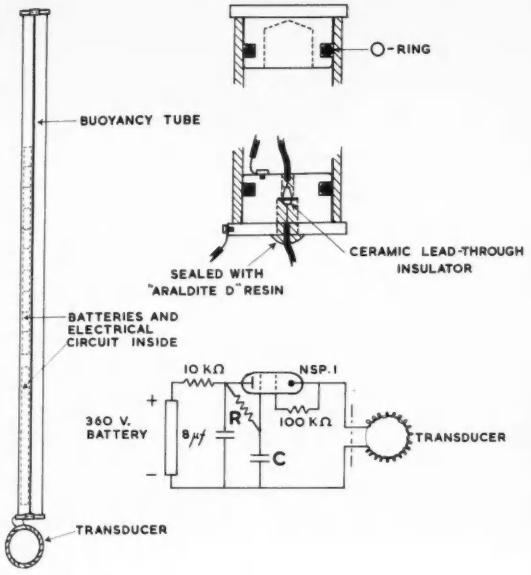


FIG. 1. The internal parts of the "pinger", consisting of a string of batteries, electronic circuit components, and acoustic transmitter. (Because the signals received make a "ping" sound, the instrument has been named "pinger".)



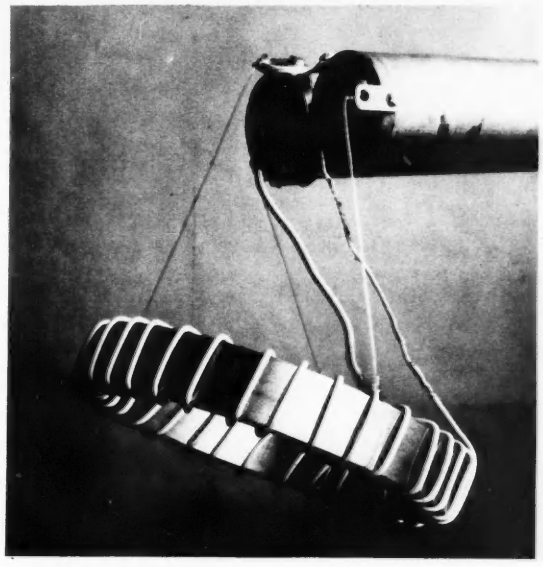


FIG. 2 (*left*). Circuit diagram of "pinger". Resistance and capacity are chosen to give the required pulse repetition rate.
FIG. 3. The acoustic transmitter of the neutrally buoyant float, the "pinger".

thene parachutes, but this proved too difficult and Dr Swallow (1955) then devised a transmitter which can be made to sink to a certain depth and to remain there, drifting with the water. The subtlety lies in finding an arrangement which adjusts its density to the increasing density of the water, as the balloon adjusts its density to the increasing rarity of the air. The essential feature is an aluminium tube which, when sealed at the ends, is less compressible than sea-water. If the tube is loaded with a weight to make its average density greater than that of the water, it sinks; but as it goes down its density increases less rapidly than that of the water because of its lower compressibility, and eventually it reaches a depth where the two densities are equal. After that it does not sink farther, but drifts along with the current.

Two ten-foot lengths of aluminium scaffold-pole, sealed at the ends, are sufficient to carry an acoustic transmitter which runs from dry batteries and sends out a sound-pulse every few seconds. By listening to these sound-pulses with hydrophones fitted 100 feet or so apart in the ship, it is possible to take bearings of the float and to check its depth. The ship's position must be known very accurately every time a bearing is taken, and the usual method is to use a tightly anchored buoy which can be seen on the ship's radar as a mark. The position of the buoy is usually checked by echo-sounding and sometimes radio-navigational aids can be used.

A number of measurements have been made of the currents and tidal streams at various depths. The most recent work done by collaboration between the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, and the U.K. National Institute of Oceanography is the comparison of the pressure distribution and water movements at different depths below the Gulf Stream off the coast of South Carolina. Near the surface there was plenty of evidence of the strong northward current, and at 1500 to 2000 metres there was little or no current. Seven floats moving at depths below 2500 metres moved southwards, and one of them, at 2800 metres, moved twenty-three miles south in sixty-six hours.

This shows that there can be currents near the bottom of the sea which are quite considerable, even when compared with surface currents; measurements in the middle of the ocean basins show weaker movements, but there may be places with still faster currents, and it is clear that we must take account of them in developing a theory to explain the surface currents and water circulation as a whole. It will take some time to fit together the results of the current-measuring and water-sampling of this latest experiment, but there is little doubt that the results will give us a good idea what to do next. The instrument and the co-operation between the U.S. and U.K. laboratories are only two more stages in a long investigation, but they are very promising.

BIBLIOGRAPHY

Swallow, J. C., "A neutral-buoyancy float for measuring deep currents", *Deep-Sea Research*, 1955, vol. 3, pp. 74–81.

Swallow, J. C., "Some further deep current measurements using neutrally buoyant floats", *Deep-Sea Research*, 1957, vol. 4, pp. 93–104.

Swallow, J. C., and Worthington, L. V. "Measurements of deep currents in the Western North Atlantic", *Nature*, 1957, vol. 179, pp. 1183–1184.

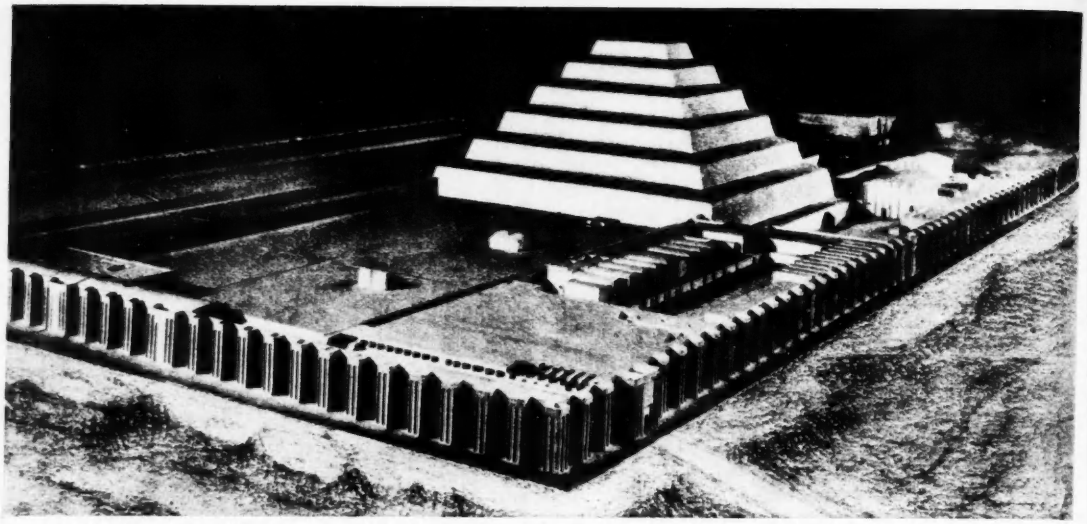


FIG. 1. Looking down at SE. corner on model of the Step Pyramid and surrounding buildings. (*After* "Sakkara, the Monuments of Zoser," *by Drioton and Lauer.*)

IMHOTEP THE FIRST SCIENTIST?

A. J. ARKELL

Department of Egyptology, University College, London

Most visitors to Egypt know the Step Pyramid of Sakkara, some fifteen miles south-west of Cairo, on the edge of the desert plateau south of the best known group of three pyramids at Giza, due west of Cairo. The Step Pyramid stands out as unusual among the many other pyramids that line the edge of the western plateau; but a generation ago little had been left to the eye by the destructive hands of time and the stone robber. Since then, although much remains to be done, and parts of the work have been irretrievably damaged, archaeology has been able to reconstruct part and recover much of the wonderful complex of stone buildings of which the pyramid itself was the focal point. Practically all this reconstruction has been done by a gifted Frenchman, Jean Pierre Lauer, who has devoted much of his lifetime to that work, and would no doubt have devoted to it all the rest of his life, had not the present political situation expelled him from Egypt. Even before he left, the work of reconstruction had come almost to a stop from lack of funds.

Fig. 1 is a model made by M. Lauer which shows what the Step Pyramid and its surroundings must have been like soon after completion. All the archaeological evidence, which is too long and detailed to be given here, points to this having been the first extensive use of stone masonry in the history of man. Yet when one looks at M. Lauer's reconstructions on the spot, the mind at first refuses to accept the evidence. The work, however, contains in itself clear evidence of a mind struggling to improve its control over a new material, and experimenting all the time with new forms for that material. First and foremost, the size of stone blocks used was changed several times during the construction, and always the tendency was to increase the size of the block. The first consideration was no doubt ease of transport and handling, but the mind of the master builder must soon have realised that increase in size gave increased strength to the construction; and he no doubt devised methods to facilitate the transport of the blocks. The almost complete stripping of the casing stones from the pyramid has revealed evidence of changes in the size of block as the work advanced, and also of changes in the design of the actual pyramid.

HOW IMHOTEP'S IDEA ORIGINATED

The original superstructure (built with the smallest stone blocks) was not a pyramid at all but a *mastaba*, a rectangular erection with slight batter or slope to its sides, representing (in more permanent form) the mansion of those days, which was almost certainly constructed of timber. This form of superstructure for the tombs of the great had been introduced by the newcomers who formed the First Dynasty of Egypt c. 3000 B.C. Prof. W. B. Emery, who has been excavating a series of large First Dynasty graves at Sakkara, realised when excavating the grave of Queen Her-Neit in the winter of 1955–56 that when this form of superstructure was introduced, the original grave mound over the tomb was not levelled but incorporated in the superstructure, being at one stage covered with a layer of bricks and in a later tomb with a series of layers of bricks built into a kind of pyramid with low steps. The reason for this must be that the mound over the grave was of ritual importance. In the present state of our knowledge, with

nothing known about the superstructures over the great tombs of the Second Dynasty—although the evidence probably awaits archaeologists at Sakkara—this stepped mound over the tomb of Nebetka from the end of the First Dynasty looks as if it must have given Imhotep, the architect of King Zoser Neter-khet, first king of the Third Dynasty (c. 2700 B.C.), the idea of producing a huge step-covered mound in stone over his master's tomb. This was at first built with four steps, but as his control over his material increased with experience, he altered it to the six-stepped erection that we know today, thereby increasing the effect. Unfortunately we have no certain knowledge as to why the mound over the tomb was of ritual importance, or what that ritual importance was. But the fact that still today in Darfur children at play are not allowed to make small mounds of sand when the rains are anxiously awaited, because the mounds are likely to stop the rain, points to a time when mounds of sand were of ritual importance in sun-worship. Whether that was the case in the First Dynasty, we do not know; but it probably was, for a remarkable ivory comb found in a First Dynasty grave at Abydos shows that the chief First Dynasty god, the falcon Horus, was already associated with the sun at that early time. In this comb the god is shown as a hawk in a boat, no doubt the boat of the sun, below which two outspread wings—no doubt those of the divine falcon—overshadow and protect the king's name written on a *serekh*, the representation of the front of the royal palace, on which is written the king's name, and on the roof of which is perched another falcon; presumably to show that the king, the occupant of the palace, was the representative or emanation of the hawk god on earth. Thus it appears probable that, in making this huge stepped mound over the king's grave, Imhotep was providing a permanent stairway by which the spirit of King Zoser after his death could ascend to the sky to his true home with the sun god, with whom at death he was probably thought of as being assimilated. Indeed, the king's Horus name, Neter-khet, written on the *serekh*, means "the god in the flesh".

That Imhotep was high priest of Heliopolis, the city of the sun and the centre of sun worship, which by the Third Dynasty must have been increasing in importance, we know from the inscribed base of a broken statue of King Zoser found in January 1926 near the Step Pyramid, which apparently indicates that Imhotep, who is given a number of titles, dedicated the statue to the king. The titles translated read "The Chancellor of the King of Lower Egypt, chief under the King of [Upper Egypt], Administrator of the Great House (Pharaoh)*, Hereditary Noble, High Priest of Heliopolis". It was in the next dynasty, the Fourth, when the pyramids first assumed true pyramidal shape (possibly influenced by the angle at which the sun's rays may be often seen descending from a cloud in the afternoon sky in Egypt), that a king's name was first compounded with that of Ra. He is Kha-f-Ra ("his appearance is Ra"), known to the Greeks as Chephren, the builder of the second pyramid of Giza. That dynasty was eventually replaced by the priests of Ra from Heliopolis themselves. Numerous magic texts, which no doubt had been in the possession of the priests of Heliopolis and with which the priests become kings first covered the walls of the burial chambers under their pyramids in the Fifth Dynasty, refer to the pyramid as an "ascent to the sky", or a kind of Jacob's ladder. Indeed the Egyptian word for pyramid apparently means "a place of ascent".

* Great house—*Per Ur* in Ancient Egyptian has become "Pharaoh" in English, and is the origin of the Turkish "Sublime Port".

IMHOTEP BREAKS CONSERVATISM

In the First Dynasty tombs, from which the Third Dynasty Step Pyramid was evolved—even King Zoser constructed at Beit Khallaf near Abydos in Upper Egypt a tomb of First Dynasty *mastaba* type in the usual sun-dried mud brick—the emphasis was all on the continuation after death of life on earth in the tomb, which was called "the eternal home" and which was provided not only with ample stores of food and drink, furniture and tools for the use of the dead man's spirit but with women and servants, buried around the tomb to serve the needs of the deceased in the hereafter as they had done in life. It must have needed a master mind to overcome the inevitable conservatism which would have resisted any change of ideas in such matters, and to direct men's minds to the more spiritual idea of an afterlife in the sky instead of on earth—as the builder of the Step Pyramid seems to have done in no uncertain fashion. The ancient Egyptians were, however, never wholly logical, and it is typically Egyptian that the mind that was responsible for directing their thoughts to an afterlife in the sky should at the same time have introduced the use of a new material to render the structure over the tomb, the earthly home of the dead king, more permanent.

The rectangular superstructure over the large First Dynasty tombs was about 50 yards long and panelled or recessed, apparently in imitation of the actual movable house constructed of timber planks that were lashed together and so had to overlap one another. The enclosure wall of the Step Pyramid was about ten times as long as a large First Dynasty *mastaba*, and to it were transferred the recesses characteristic of the actual tomb superstructure itself in the First Dynasty. The height of this wall was 20 royal cubits or about 30 feet. In the upper half of the wall there were small rectangular recesses imitating the ends of timber beams usually built in to the upper part of large mud-brick walls to strengthen them. There were in all fourteen doorways in this enclosure wall, all of them dummies except the one in the SE. corner, where a narrow passage gave admission into a colonnade consisting of two rows of graceful ribbed stone columns, painted red to imitate wood. None of the columns in the Step Pyramid complex is free standing, but each is supported by a short wall running at right angles to the boundary walls of the colonnade, and in a small hall in which the colonnade ends, the roof is supported by eight columns, of which each pair is joined by a similar strengthening wall. These supporting walls for columns are part of the evidence for their being at the dawn of stone masonry; for the builders had

FIG. 2. Half-open door in solid stone leading from entrance colonnade to the Step Pyramid compound. (*Photo by the Author.*)

not yet learned to use large enough blocks of stone to make free-standing columns safe. They were also at a loss to know how to represent doors, which moved in opening and shutting, in immovable stone; doors are therefore represented either open, shut, or half-open (Fig. 2). On the half-open door between the colonnade and the open space inside the enclosure are represented the ends of the wooden crosspieces to which the planks of the door were nailed, all carefully imitated in stone.

Near the end of the colonnade and close to the western enclosure wall is a tomb the purpose of which is not yet understood. It is secondary to the main tomb, which is under the pyramid and is covered by a rectangular *mastaba*-like superstructure with a rounded roof. Near this are the remains of a chapel, where the wall is crowned by a frieze of cobra-heads or uraei, the well-known emblem of the cobra goddess of Buto, guardian of the kingdom of Lower Egypt. This makes it probable that as king of both Upper and Lower Egypt it was considered essential for the king to have a second symbolic tomb in addition to his main tomb. That such duplication did occur in the Step Pyramid complex is confirmed by many of the other edifices which have been brought to light within the enclosure. These must represent in stone for permanency the temporary booths, shrines, etc., in which the king celebrated—usually in the thirtieth year of his reign—the *Hebsed* or Jubilee festival (in which all ceremonies were duplicated so as to apply to both kingdoms), the intention being to prolong the king's life and reign. Indeed Imhotep here must have aimed at securing immortality for King Zoser by providing in the new and apparently permanent medium, stone, for the perpetual celebration of his jubilees. To our present purpose these buildings are of the greatest importance, for like all the stone buildings associated with the Step Pyramid, they point out to those who have eyes to see, not only the creative imagination of the architect and his skill in thinking out and developing the new technique of stone masonry, but his unique curiosity that led him to be one of the first men to study nature and feel the inspiration of its beauty. The frieze of cobra-heads that he created and which we have already noticed is more snake-like than any of the thousands of copies that were made by subsequent generations.

FIG. 3. Papyrus columns in the Step Pyramid compound. (*After Lauer*, "Pyramide à degrés".)

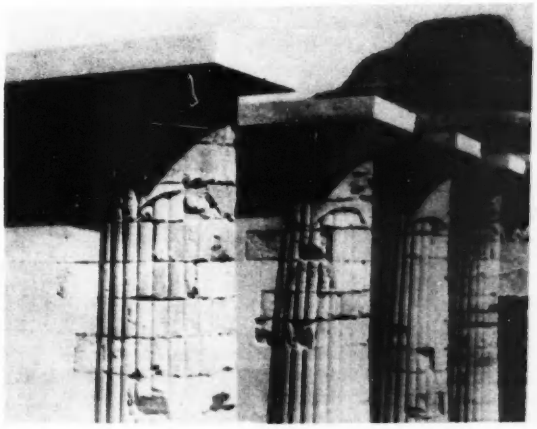
NATURAL PLANT LIFE IN THE COLUMNS

In the complex of buildings around the pyramid there are at least five styles of column all, as we have already noted, engaged and all of them based on accurate observation of plants. Two of them, the lotus and papyrus columns, like the frieze of uraei, formed prototypes which were copied over and over again by Egyptian architects for nearly 3000 years. Yet none of the subsequent papyrus columns is more graceful or as near to the natural papyrus plant as those designed by Imhotep (Fig. 3), in which the triangular stalk of the papyrus is copied with remarkable success. It took an Egyptologist who was also a botanist—the late Prof. P. E. Newberry—to recognise that two of the other types of column, which though graceful were not copied subsequently, were derived from the Giant Fennel (*Heracleum giganteum*), which must have then grown in Egypt and the actual stalks of which may have been used as supports for light shelters, as Mr I. E. S. Edwards has suggested.* Figs. 4 and 5 show examples of these columns, of which the shafts are either fluted or ribbed. The capitals are clearly inspired by the pendant leaves which occur alternately on the stalk of the Giant Fennel, although for the sake of symmetry the leaves are shown as opposite one another in the capital (Fig. 6). The two forms of the shafts reveal accurate observations of nature, for the stalk of the Giant Fennel is ribbed when

* *J. Egypt. Archaeology*, vol. 35, p. 123.

FIG. 4. Fluted columns of a temple (reconstructed) with the Step Pyramid behind. (*After Lauer*, "Pyramide à degrés".)

FIG. 5. Upper half of ribbed columns (reconstructed) in the hall at the west end of the entrance colonnade. (*After Lauer*, "Pyramide à degrés".)



green and fluted when dry. Traces of red-brown paint have been observed on these stone columns, which make it likely that, as in the architectural details already noticed, Imhotep was perpetuating in stone the actual woodwork of the palace in which King Zoser had lived in life. It may be argued, since none of this woodwork has survived to prove or disprove it, that wooden columns inspired by plants existed before Imhotep. If that argument is advanced, it cannot be disproved; but to me, everything about the Step Pyramid proclaims that it is the creation of a great and original mind, and it seems quite probable that that mind was responsible for thus making use of the beauty of nature to adorn its creations in the new medium, stone.

Some support for the theory that Imhotep was an early botanist, a close observer of plant life, may be derived from the fact that centuries later in his own country Imhotep was worshipped as the first inventor of the art of medicine and healing. A papyrus from Oxyrhyncus dating from the first–second century A.D. is known which purports to be the copy of a document dating from the Fourth Dynasty, and found in the temple of Imhotep in the Thirtieth Dynasty (fourth century B.C.), which shows that the sick resorted to his temple for incubation. The treatment of sickness is still considered, in backward parts of the Nile valley, the province of

FIG. 6. Giant Fennel capitals from the *Hebsed* chapels. (*After Lauer*, "Pyramide à degrés".)

native practitioners known as "root men", who treat their patients with pure magic and with combinations of roots, some of which no doubt have medicinal values. It is more than likely that an original mind which studied the forms of plants and knew that some of them were edible, would experiment with parts of them for the treatment of sickness, and obtain sufficient success to give him a reputation which, once established, would grow with repetition.

That Imhotep did impress his contemporaries with his wisdom is clear from such literature as has survived. In the Eleventh Dynasty (before 2000 B.C.) we have the oldest surviving version of the song sung by the harper at funeral feasts, which includes: "I have heard the discourses of Imhotep and Hardedef (a Fourth Dynasty prince), whose words men still repeat everywhere, but where are their houses (probably=tombs)? They are destroyed as if they had never been." Other versions of this song still survive on the walls of Eighteenth Dynasty (c. 1400 B.C.) tombs at Thebes.

If the Oxyrhyncus papyrus already mentioned is reliable, it provides evidence that as early as the Fourth Dynasty Imhotep was worshipped as a demigod, for it states that his worship was neglected in the disturbed times preceding the reign of Mycerinus, who restored his worship and endowed his temple. If this is the case, his tomb must have become, as it quite naturally might, a place of pilgrimage after his death. It was no doubt during this period that scribes developed the custom of pouring a libation to Imhotep, "the greatest of scribes", from the water vase with which they prepared their pigments. We have a reference to this custom in an inscription from a tomb of the reign of Amenhotep III (1408–1372 B.C.): "May the priests stretch forth for them their hand with water upon the ground, as is done for Imhotep from the water-vase." A number of bronze statuettes exist showing Imhotep as a demigod seated reading an unrolled papyrus on his knee. One of them, now in the Wellcome Historical Medical Museum, in London, is unusual as having a row of uraei arranged round the seat as decoration. It is possible that this is connected with Imhotep's frieze of uraei recently restored at Sakkara. There are several of these statuettes in the Petrie Collection at University College, London (Fig. 7).

Probably during the Persian domination of Egypt, c. 500 B.C., Imhotep was raised to the status of a full god, as the third member of the trinity of Memphis, which consisted of Ptah and Sekhmet, being known by phrases such as "Great One", "Son of Ptah, who giveth life to all men". Indeed by the Ptolemaic period, he had become the principal god worshipped at Memphis, and under the Greek form of his name, Imouthes, was equated with the Greek god of medicine Asklepios (Aesculapius). His temple at Memphis, like his tomb, has yet to be found, but there is still in existence on the island of Philae, near the Second Cataract at the other end of Egypt whither his worship spread, a Ptolemaic temple built for his worship about 250 B.C.

FIG. 7. Bronze statuettes of Imhotep in the Petrie Collection at University College, London: three of him as a demigod reading a roll of papyrus, and (on the extreme right) one of Roman date from Memphis representing him as a god. (*University College photo.*)

THE EGYPTIAN LEONARDO

For a historical person other than a king to become a god was most unusual in ancient Egypt. Imhotep must have been a most unusual person, indeed a genius akin to Leonardo da Vinci, whose intellectual energy and curiosity were inexhaustible, and whose charm and ability were such that he succeeded in everything to which he set his hand. In art he perfected the traditions of the past, while in science he was a pioneer. Knowing and doing attracted Leonardo equally. His thirst for knowledge was first aroused in him by the desire to perfect the images of beauty and power which it was his business to create. Thus he developed a passion for knowledge for its own sake, and he then turned to practical use the mastery his studies gave him over the forces of nature. Imhotep must have had a brain of the same type as Leonardo. He too must have studied nature closely and used the knowledge that his studies gave him both to create in a new medium the thing of beauty that the Step Pyramid complex undoubtedly was, and also perhaps to found the science of medicine.

SON ET LUMIERE AT GREENWICH

ANDRE MILON

Director of Research and Development, Pathé Marconi, Paris

Son et Lumière is a spectacle which takes as its actor a natural or man-made feature and brings it to life through a variation of lighting effects and through an accompaniment of the spoken word and music. It must take place at night and the audience must either stand or sit, but not walk about if it should achieve its maximum psychological impact. It is one of the few instances of an enhanced aesthetic enjoyment brought about by scientific research; it has rightly been called a ballet of sound and light. In France, over thirty of these spectacles are now in existence. The first in England, the Queen's House and the Royal Naval College at Greenwich, had its première on August 1, 1957; it was sponsored by *The Daily Telegraph* on behalf of the Ministry of Works and directed by H. Holt Ltd.

TYPES OF SON ET LUMIERE

Son et Lumière need not necessarily take a grandiose historical setting but can be centred on a single church or a small castle. It had its origin in 1940, when M. P. Robert-Houdin—the producer of the French and Greenwich spectacles—saw the Château de Chambord brilliantly illuminated by lightning. The first realisation of his idea, to reproduce these magical effects by artificial light, came in 1952 and since then it has grown into six distinct types of spectacle.

The first type of Son et Lumière takes as its setting the grandiose national historical pattern, like Versailles, Vincennes, and now at Greenwich; actors like Sir Laurence Olivier speak the words of kings and re-create the country's history. The second type is the local equivalent of the first, perhaps a castle on the Loire like Blois, where the emphasis is on the local history of the area. The third is called an oratorio, taking a sacred or a national theme and bringing it to life by lighting effects on woods, rivers, gardens, and so forth. As an example of this type the one at Domremy may be quoted, the birthplace of Joan of Arc. But instead of a concrete theme, a purely abstract, metaphysical concept may provide the leit-motif, as, for example, the contest between good and evil; this was used at Albi with its 13th-century cathedral as the main setting. Another kind may be an epic Son et Lumière. As an example one might quote the one at La Palisse, itself bereft of history, but used as a background to a poem narrating the story of French knights, from Roland to the fighter-pilots of the last war. Finally, Son et Lumière may simply use a fairy-tale as its theme, and embellish it with music and with light.

Perhaps in years to come these different types will also be seen in England. There is certainly no lack of either the right architectural setting or of the poetic and musical accompaniment; French tourists to England will then enjoy them as much as English visitors to France have been enchanted by the different types of Son et Lumière in France.

THE SOUND

There is no limitation to the sound effects which can be used. At Greenwich they include music, the spoken word, the hoofs of horses, the flow of water, and the sounds of battle. The recording is carried out on standard 6·35 mm. magnetic tape, using two or three tracks; particular attention must be paid to the mixing and to the queueing of actors and effects, as the tape will be used, perhaps, for several hundred play-backs. It is by no means as ephemeral as a radio broadcast. As the recording will be of a stereophonic nature, the meticulous care in the preparation of the tape will be readily understood. During the performance the tape is played

at the standard speed of 15 inches per second and the level of the sound is manually controlled. After pre-amplification, the sound is passed via an attenuator to the power amplifiers, each of which can produce, in the range of 50 to 100 kilocycles, an output of 80 watts with less than 2% distortion; if a 5% distortion is tolerated, then the output can be raised to 110 watts. At Greenwich ten of these amplifiers were used; they were made by Pathé Marconi, Paris.

The loud-speakers are of special construction, and the result of considerable research. They employ 15-inch moving coils fixed inside special cabinets, called *conque elipson*; they are similar to reflex cabinets with the speaker at one focus of an ellipsoid, the other focus being the reflecting surface itself from which the cone of sound issues. The clarity and the power of the sound is one of the reasons for the success of the entire spectacle.

THE LIGHT

Again there is no limitation to the colour and diversity of the lighting effects which can be produced with the special equipment developed for Son et Lumière. At Greenwich a total of 180 projectors were used, ranging from ½ to 3 kW in power. Their construction, by the Compagnie des Lampes, Paris, is unorthodox and consists of a front-silvered bulb and a back-reflector. The reflector itself is composed of a number of vertical blades, pivoted and adjustable from the outside of the projector housing. These blades are so arranged that a beam of light of rectangular cross-section can be produced, the height and width of which can be adjusted to suit particular needs. Coloured light is produced by coloured reflector-blades.

The control of the lights is carried out manually during the show by means of a switchboard, exactly similar to the type employed in theatres; the intensity being adjusted through transformers, and not through resistances. Theoretically it might well be possible to control the lights through a master magnetic tape on which all adjustments had been recorded; however, the cost of such an installation would be ten times as much as the present one.

Science has certainly contributed greatly to our enjoyment of the beautiful architecture of Greenwich. Perhaps it will itself provide in the not-too-distant future the subject of a Son et Lumière spectacle, and one might suggest that against the background of Calder Hall the story of atomic research may be told. Also, the giant radio-telescope at Jodrell Bank might well be used to bring to life, in an exciting and dramatic manner, the history of astronomy from most ancient days to the present.

(*Illustration by courtesy of* The Daily Telegraph)

TWENTY-FIVE YEARS AGO

SHORT WAVES, BALLOONS, AND PIGMENTS

DISCOVERY for September 1932 contains a number of interesting items. Under "Notes of the Month" we reported the Marchese Marconi's successful experiments in the use of ultra-short waves, which showed "that communications may be made over distances hitherto thought impracticable owing to the curvature of the earth. The experiments were carried out over a distance of 170 miles, using an apparatus of low power fitted with portable reflectors. In earlier experiments it had only been possible to traverse a distance within the normal horizon, and instead of the heavy and cumbersome apparatus, a light portable set has now been devised for this purpose. The experiments open up interesting possibilities for the future of ultra-short waves, and further tests will be keenly watched in this country."

Then there was Prof. Piccard's balloon ascent to a height of ten and a half miles. "Last year," we said, "the Professor ascended nearly ten miles with the object of measuring the cosmic rays at a height at which they had not been absorbed by the atmosphere. Human life is, of course, impossible at such a height, and the ascent was made in an airtight 'laboratory'." In his latest attempt he remained up for as long as twelve hours, and new observations of the stratosphere were made. "We do not yet know what part the penetrating power of cosmic radiation may play in such every-day processes as the formation of cloud. If Prof. Piccard's observations provide a solution they will be of great value to meteorology. It is possible that the electrification of the clouds is induced in some way by the radiation. There are many other problems connected with the stratosphere which are likely to be solved by observations at high altitudes."

An article on "Pictures under the Searchlight of Science" by A. P. Laurie, describes the scientific examination of old masters: "The first and most important examination of a picture is with the microscope, which should be arranged to travel on a long horizontal bar. Repaintings are readily detected, the paint bridging old cracks, an idea of the age of the picture obtained from the appearance of the pigments, and some of the pigments themselves identified by their appearance under the microscope. . . . The next step is to examine the pigments by means of tiny specks removed with the point of a hypodermic needle. These are subjected to optical and chemical examination under the microscope. Modern pigments are identified, and among old pigments some were used at definite periods, which enables one to approximate to a date in certain cases. . . . Samples are also taken where white lead has been used, the white lead dissolved by acid and the film subjected to an optical examination and to staining solutions. Oil can be distinguished from egg and assistance given in determining the date of the picture by measuring the refractive index of the oil. X-ray shadowgraphs give information about under-painting and may reveal other useful facts, and ultra-violet light reveals repairs and repainting. The final result of all these methods is to supply a lot of data which are invaluable to the connoisseur, in addition to proving actual fraud when it occurs."

LETTERS TO THE EDITOR

Congestion at Road Junctions

Sir:

Dr Courtney-Pratt (DISCOVERY, May 1957, p. 212) argues that the flow of traffic entering a major road from a "T" junction would be increased if the island often put there were displaced to the right, so as to allow two lines of vehicles on the left and only one on the right of the minor road. The argument is convincing, though a possible objection is that traffic islands in an unexpectedly eccentric position might be run in to by unobservant motorists.

Does a traffic island here, however, really serve any useful purpose at all? It may sometimes be of value as a refuge for pedestrians, but otherwise it is intended only to prevent cutting the corner, which it does at the expense of narrowing the road by a couple of feet at an important bottleneck. But although it is dangerous to cut a blind corner, these corners are not blind. The only drivers seriously tempted to cut such a corner are those coming from the left and turning in to the minor road, and they can see perfectly well if there is anything in it while they are crossing the main stream of traffic to approach the junction.

The answer, surely, is not to displace the traffic islands at this sort of junction but to remove them altogether, and then to allow the double lane on the left, as suggested by Dr Courtney-Pratt. But this should be indicated by a white line on the road and not by an obstruction placed in the middle of the stream of traffic.

C. B. GOODHART

Cambridge.

Giant Polar Tanks

Sir:

Mr D. Hill's letter in your July issue (p. 311) has aroused some interest among those engaged on antarctic research, and his suggestion of giant tanks for polar geophysical exploration has reopened the question of new modes of transport in polar regions. Particularly for the field scientist there has been a natural urge for improved transport methods, which would give *maximum mobility*, and hence working efficiency. The many countries participating in polar exploration at present have all experimented with mechanical transport and new vehicles have been specifically developed for various purposes. Unfortunately, nearly all the new vehicles have their field limitations, which are primarily governed by fluctuating weather conditions and the country being explored.

There is general agreement that for geological, geophysical, and survey work, which, especially in West Antarctica, is localised in the coastal areas, the use of helicopters is almost ideal during the summer season.

The first question one asks about Mr Hill's polar tank is whether it would be an all-weather vehicle. Clearly, it would be expensive to develop and build. Maintenance in the field would probably be costly and would necessitate a highly trained crew of technicians. A tank of this size would have to be of particularly light-weight construction, possibly involving the use of plastics and fibre-glass sheathing on a strong aluminium alloy framework. It would have to be completely driftproof, suitably insulated against cold, and possess proper interior heating facilities.

It seems to me there may be many practical disadvantages of a tank of the dimensions envisaged. The tank would have to be sailed to Antarctica rather than carried on board a ship. This would clearly involve landing difficulties, because suitable beaches giving access to the hinterland and polar plateau are not easy to find. Therefore, would it not be possible to prefabricate the vehicle and construct it in the Antarctic?

If such a tank were to be snowed and iced up during a severe blizzard, it would be a major digging operation to recover it. In fact, the probability of not being able to recover it would be extremely high. A tank of these proportions would undoubtedly be able to cross large crevasses at right angles, but I doubt whether it could ever be recovered if it capsized sideways into some of the wider chasms, which are not unknown in Antarctica.

Mr Hill seems to have a mistaken impression of polar explorers spending most of their time "keeping alive and moving around". Perhaps this is a repercussion of recent Press reports? The essence of antarctic field work *is* the ability to travel efficiently and observe accurately in addition to maintaining life irrespective of the mechanism of transport. To drive a machine over hundreds of miles is completely devoid of the fascination of sledging with a team of well-trained huskies!

RAYMOND J. ADIE

Falkland Islands Dependencies Survey, The University, Birmingham.

Atom Bombs for Seismology

Sir:

My attention has been drawn to a paragraph in the May 1957 DISCOVERY referring to the proposal to detonate atom bombs for seismological purposes. I should be grateful if you could kindly correct the possible impression that the proposal was put forward by me in my capacity as chairman of the Australian IGY Committee. The proposal was put forward by me in 1955 as President of the International Association of Seismology and the Physics of the Interior of the Earth. It had originally been hoped that the proposal might be incorporated as part of the IGY programme. When, however, a sister Association expressed concern at possible interference with certain contemplated IGY experiments, the idea of associating the proposal with the IGY period was dropped. I shall be referring to the proposal during part of my presidential address at Toronto this month—but not as an IGY project.

K. E. BULLEN

Department of Applied Mathematics, University of Sydney.

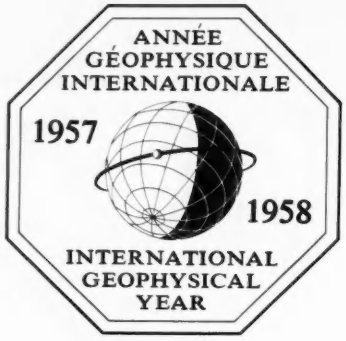
The Philosophy of Synthesis

Sir:

In the interesting article, "The Philosophy of Synthesis", by A. Godfrey Cruft (DISCOVERY, July), one statement deserves comment: "The laws of science are not man-made but man's attempt to understand the laws of God." Surely science recognises no laws of God, who is by now, as Huxley put it, "no longer a useful hypothesis". Let science go ahead on its own feet without the unnecessary entanglements with orthodox religions, which in any case are in the process of fading out.

J. D. AGNEW

Department of Zoology, University of Pretoria, S.A.



THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Just before the IGY opened (July 1) statements by senior Soviet scientists and Soviet Press references divulged some of the details of the Russian artificial earth satellite. A document on Soviet rocket and satellite research, dated June 10, has now been deposited with the CSAGI reporter in this field. We here reproduce the substance of this document and the important addition on the exchange of rocket and satellite data.

The Russian Satellite

The document on the Russian IGY rocket and satellite programme of which we quote below all but the preamble does not mention some of the essential facts about the satellite that have been released in other ways. For convenience, therefore, all the known facts about the Russian satellites' flight details are given here together, whether the data has been derived from the following document or from statements made in Russia recently by the President of the Soviet Academy of Sciences and others.

Russian satellites will not be of one kind but of several. These will differ in size. The range of sizes has not yet been given. The height of orbit of these satellites above the Earth will be between 125 and 300 miles high. (The American satellite will follow an orbit of perigee about 300 miles high and apogee of 1200; at these heights it is expected to remain aloft for several weeks.)

The satellites will be launched from a site in Russia between the 50th and 60th meridians. (This meridional band extends across Franz Josef Land in the Arctic and through Russia passing between the Aral and Caspian Seas, and also takes in Mirny, the main Soviet station in the Antarctic. Russian rocket launchings will take place from three sectors, also located along this band.)

The orbit of the satellite, in contrast to that of the Americans, will be on the whole circumpolar. The satellite will be launched at "a slight angle to the meridian"; this will give a generally north-south passage over the Earth's surface. Due to the rotation of the Earth a Soviet satellite will be observable "in all the areas of the Earth except the central areas of the Arctic and Antarctic"—provided of course it makes enough circuits.

In the CSAGI document the research work to be conducted from the Russian rockets and satellites is all gathered together. It is possible, however, taking a statement by the President of the Soviet Academy of Sciences and the internal evidence, to show that the leading satellite studies will be concentrated on cosmic rays, geomagnetism, and the population and penetrative power of meteors and micro-meteorites (meteoric dust) at satellite heights. It also appears that the Russians have had the same difficulty as the Americans in accommodating all the experiments scientists wanted to have performed, and that the competition for space—within the satellites that is—has been acute.

Another way in which the arrangements now announced appear to differ from those of the Americans is in the greater emphasis put on the recovery of photographic records as against a wholehearted reliance on telemetry. If this applies equally to the satellite as to the rocket programme, it suggests that the Russians are planning the ambitious step of *recovering* material from satellite flights—implying that they consider they have solved the pre-eminent difficulty of re-entry into the Earth's atmosphere.

No mention has yet been made of how the satellites are to be put in their orbits, nor of the arrangements intended for tracking them. At last autumn's Barcelona conference, however, agreement was reached for all IGY satellites (whether Russian or American) to operate the internal radio transmitter on the same wavelength, namely 108 mc/s.

The *preliminary* programme of research, as set out in the recent Soviet communication on rockets and satellites to Dr Berkner, follows:

Atmospheric Parameters

"Measurements will be taken of the pressure, temperature, and density of the air at various altitudes and also of the structure of the atmosphere. Together with the measurements of the density taken by manometers, certain data will be obtained by observation of the orbit of the *satellite*. During the movement of the satellite, owing to atmospheric resistance, its orbit will gradually come closer to the Earth. The study of this makes it possible to determine the laws of density distribution at altitude.

Optical Properties

"Measurements will be made of the altitude and the brightness of the fluorescence of individual layers of the atmosphere. The scattering of light in the atmosphere will also be studied, as well as optical phenomena on the horizon.

Ultra-Violet and X-Radiation

"The air envelope is a filter for solar radiations. The atmosphere passes light beams with a wavelength not less than 0·29 micron. The penetration of rockets and *satellites* into the upper layers of the atmosphere will enable us to study the ultra-violet and x-ray sections of the solar spectrum; also it will be possible to determine the rôle of this solar radiation in the formation of the ionosphere, and to study the absorption of the radiation in various layers of the upper atmosphere.

Soft Radiation and Aurora

"Corpuscular emission of the Sun calls forth sporadic violent variations of the Earth's magnetic field and disturbances in the ionosphere. Affected by the corpuscular streams from the Sun, the ionospheric disturbances bring about long-period disturbances of short radio-waves propagation.

Solar corpuscles bring about several other phenomena in the upper layers of the atmosphere, for instance the aurora. However, the nature and the intensity of the corpuscular radiation remains to be studied.

It is intended to measure the intensity of the solar corpuscular radiation, to determine the nature of the corpuscles, and the velocity of their penetration into the atmosphere, both at normal and during highly active periods of the Sun."

The Russian satellite should provide a unique opportunity for experiment in this field, since its orbit alone will pass through the auroral zone.

Cosmic Rays

"It is known that the primary cosmic radiation consists mainly of hydrogen nuclei (protons), helium nuclei (α-particles), with a much smaller number of heavier nuclei (carbon, nitrogen, oxygen, and so forth).

One of the properties of the primary cosmic radiation is the similarity

between the curve of the average distribution of the elements in the Universe and the curve of the distribution of the charges of the primary component of cosmic radiation. Such elements as lithium, beryllium, and boron are rare in nature, and the number of these nuclei in the primary cosmic radiation has not been studied by experiment. In this connexion the study of the properties of the primary cosmic radiation may shed light on questions about the time of the cosmic particles wandering in the space of the Universe, and on the origin of cosmic rays.

Classed with the same range of questions should be the study of the variations or cosmic-ray intensity at various altitudes and in different geographical regions."

This, at first glance, is the most striking section of the Russian programme because it goes much further than the Americans, because of the extreme difficulty of the lithium, beryllium, boron experiment, and because of the implications of this experiment in terms of payload. Contrary to what is here claimed (that no experiment has ever been attempted to measure the quantity of lithium, beryllium, and boron in primary cosmic rays) such experiments from balloons have since 1947 exercised the increasing interest of several groups of cosmic-ray physicists, both in the U.S.A. and in Britain. These experiments have proved the impossibility of achieving conclusive results even at balloon heights (20 miles up), and with long exposures. Rockets are not suitable research vehicles because, though they go high enough, they do not remain at height for more than a few seconds. The satellite would therefore seem to provide a great possibility for these absorbing experiments—but they will not be easy and 9 lb. is thought the minimum payload for this work alone.

Ionospheric Physics

"One of the problems concerning the structure of the ionospheric layers is the determination of concentration of ions. It has been established by experiment that the concentration varies with altitude.

In this connexion the data on the ionisation of the atmosphere along the orbit of the *satellite*, or along the trajectory of the rocket, are of great interest.

The study of the radiowave passage through the ionospheric layers will greatly improve our knowledge of the electronic density, and will also give information about the degree of radiowave fading.

As to other ionospheric measurements there will be mass spectrometric measurements of the ion contents of the ionosphere with a view to the determination and verification of its structure.

Magnetic Fields

"Short periodic variations of the magnetic field of the Earth are at present associated with the systems of electrical currents flowing in the upper layers of the atmosphere. Modern data state that rings of such currents are located in Auroral polar zones (in northern and southern latitudes) and around the equator. The proof of the existence of these currents, their nature and origin are an important scientific investigation for the *satellite*. The settlement of this problem will offer new data to scientists to explain various short-period variations of the magnetic field of the Earth and their connexion with solar geophysical phenomena."

Of great interest in view of the range of latitudes that can be monitored from this satellite.

Micro-meteorites and Meteors

"The problem of micro-meteorites is of great scientific and practical importance. On the one hand, the presence of micro-meteorites in the upper atmosphere predetermines a range of physical processes influencing the state of the atmosphere. On the other hand, micro-meteorites and meteors present certain dangers to the *satellite*. Calculations show that even small particles with a velocity of 50–70 km. per second can break through the casing of the satellite. Therefore it is important to know the concentration in space and the energy of micro-meteorites. The study of the spectrum of the micro-meteorites and of the meteors regarding their mass would help us to come to a definite conclusion regarding 'meteoric danger'. This is most important for future interplanetary travel. For this purpose instruments recording the impacts (impact detectors) of meteorites will be installed in rockets and satellites.

Physical and Chemical Processes in the Upper Atmosphere

"It is intended to launch different chemical reagents by rockets into the upper atmosphere and to study the processes during their interaction with the surrounding medium.

Instrumentation of Rockets and Satellites

"The entire geophysical equipment designed for the investigation of the upper atmosphere is housed in various containers. Some of these containers make up the vanguard part of a rocket with the instruments. This is detached from the rocket a certain time after burn-out of the rocket motor. These containers reach altitudes up to 200 km. The containers are equipped with radiotelemetry or instruments with immediate photographic recording. In the latter case the containers are recovered.

Firing Sites

"The vertical firings of the rockets with a purpose of studying the upper layers of the atmosphere will be conducted in three zones located approximately along the meridian 50–60° E.

First zone—the Arctic, the Franz Josef Land, 80° N.
Second zone—middle latitudes of the U.S.S.R., 50–60° N.
Third zone—the Antarctic, mainly in the area of Mirny, 50–60° S.

The launching of the satellite will be made from the U.S.S.R. at a small angle to the meridian. The satellite will revolve around the Earth and will consequently be observed in all the areas of the Earth except the central areas of the Arctic and the Antarctic.

Rocket Distribution by Zones and Years

"First zone, 1958—25 firings.
Second zone, 1957—30 firings, 1958—40 firings.
Third zone, 1957–8—30 firings.

The Distributions of the Studied Parameters by Containers

"At every firing of a rocket or the launching of a satellite, a definite volume of the upper atmosphere investigations is being covered. When the rockets take up the containers of the first type, the study is made of the structural parameters of the atmosphere and of its typical properties, of the ultra-violet and x-ray parts of the solar spectrum, of the ionospheric phenomena and micro-meteorites.

When containers of the other type are taken up with the rockets, the range of problems studied includes the corpuscular solar radiation, aurora, and also the physical and chemical processes in the upper layers of the atmosphere.

When launching the man-made satellites the programme includes geophysical, physical, and astro-physical experiments in various combinations, and also other investigations such as the observation of the relativity theory effect, the study of the shape of the Earth, and so forth.

Schedule of Rocket and Satellite Firings

"The firing of the rockets and the satellites will be conducted approximately evenly throughout the International Geophysical Year, mainly on World Days and on occasions of increased solar activity—that is, Special World Intervals."

Agreement on Data Interchange

The following is from the text of the agreement relating to **Satellites**, drawn up by the CSAGI reporter on Rockets and Satellites, Dr L. V. Berkner, with the approval of the nations concerned, and dated June 19, 1957.

The data of value in the establishment of satellite observation stations are considered to be:

1.1. Technical and operational information on the optical tracking system: (i) visual and photographic equipment, (ii) visibility characteristics of satellites, (iii) observational methods.

1.2. Technical and operational information on the radio tracking system: (i) precision radio system (Minitrack

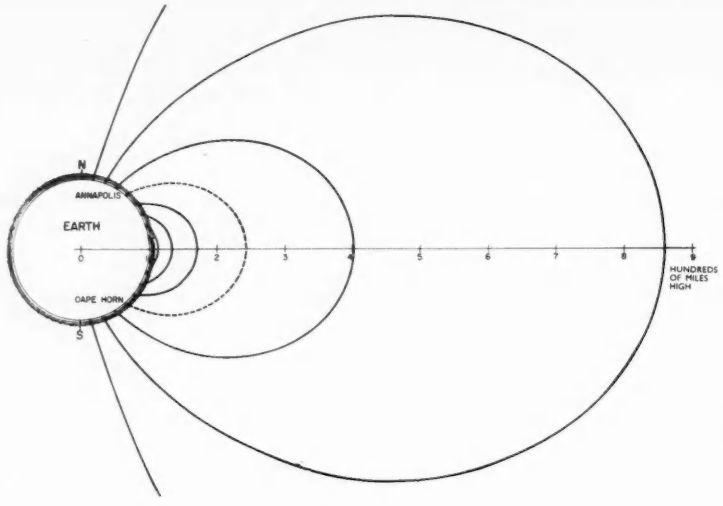


Diagram illustrates Helliwell and Gehrels' Annapolis-to-Cape-Horn experiment to see if man-made signals with characteristics of "whistler" atmospherics would behave in the same way, so confirming Storey's theory of their path of travel. Each signal, of 15·5 kilocycles, arrived twice with an interval of 0·7 second between them; that bounced off the ionosphere was 30 decibels louder and 0·7 second quicker on the journey than that travelling nearly up to 3000 miles via ionised columns along the Earth's geomagnetic flux-lines. (Speckled area represents the known ionosphere; dotted line represents the flux-lines connecting Annapolis with Cape Horn.)

Mark I) and auxiliary equipment, (ii) simplified radio system (Minitrack Mark II) and auxiliary equipment, (iii) in-board Minitrack transmitter and its characteristics, (iv) observation methods.

1.3. Technical information on satellite internal instrumentation: (i) design and instrumentation of in-board experiments, (ii) methods of data encoding and storage, (iii) feasibility of reception of telemetered signals by general observers.

1.4. Distribution of ground observation stations: (i) location of radio, visual, and photographic-group observation stations and description of facilities, (ii) recommendations by satellite-launching nations as to desirable sites for the establishment of such stations by other countries.

A similarly comprehensive agreement governs the interchange of data on **rockets**; this of course affects more nations, in fact up to ten.

The exchange of material on rockets includes reports to be deposited within a few weeks of firing at World Data Centres and for distribution, giving among other things, rocket-type, trajectory, pyrotechnics, flight-objective, experiment-objective and a preliminary statement on results of the experiment attempted. The agreement also rules that "the final conclusions of IGY rocket experiments shall be published in the open literature". It is to be supposed that this agreement covers rockets fired for the purpose of placing satellites in orbit.

The CSAGI reporter hopes that the information required, and which is listed in the Agreement, will be available for inclusion in the *Manual of Rockets and Satellites*, scheduled for publication in the late autumn of this year.

Man-made Whistles Stretch Ionosphere

A happy experiment last autumn by Helliwell and Gehrels of the Radio Propagation Laboratory of Stanford University, California, has persuaded the National Science Foundation, Washington, to put $118,000 at Dr Helliwell's disposal for the setting up of ten IGY posts in addition to those originally scheduled.

Last autumn's experiment was designed to test the theory that whistling atmospherics were due to the electrical impulses generated by thunderstorms, travelling from the seat of the disturbance, along the Earth's field of force (which sweeps thousands of miles into space before curving back to the Earth's surface). This would sort out the frequencies in time so that the higher ones would arrive first and so give the characteristic descending musical scale of the "whistler".

The experiment appears to have been a resounding success. It seems to confirm the Canadian physicist, L. R. O. Storey's, postulated origin for these "whistlers", which are a great trial to operators of long-distance radio. This discovery is overshadowed, however, by the implications of the experiment, namely that the particle density at 6000 miles high (the limit of this experiment) is still sufficient to provide a path for the passage of an electrical current —that it is "not much less than 100 electrons per cubic centimetre"—in fact, according to Dr Helliwell (1 electron per cubic centimetre has been the assumed density of particles in space for some time). This in turn suggests that the ionosphere, considered to be relatively dense through an enveloping shell beginning somewhat above 40 miles from the Earth's surface and continuing for 200 miles to about 250 miles, does not end so abruptly as has been supposed but trails off for perhaps thousands of miles into the exosphere. (The pole-to-pole flux-lines may swing out to 3000 miles from the Earth's surface.)

Helliwell's experiment was to send out a man-made whistle from the U.S. Navy's very powerful radio-transmitter at Annapolis, Maryland, and have Gehrels listen for it on a specially installed receiver in a Chilean lighthouse by the Straits of Magellan, the nearest convenient point to that on the other side of the geomagnetic equator where the flux-line originating at Annapolis cuts the Earth's surface. The signal was sent out at 2-second intervals as a pulse, on an extremely low frequency, 15·5 kc/s, corresponding to the type of the whistler atmospherics signal produced by thunderstorms. If the theory being tested was right the signal would reach Cape Horn twice with a short interval between them and a noticeable difference in definition. The reason for this would be that the signal was travelling by two distinct paths with a difference of thousands of miles in their relative length. One would bounce off the underside of the ionosphere in the classical way; the other would escape through the dense region of the ionosphere, but often that would be bent back again to the Earth's surface. It would find the most convenient electrical path along the lines of force of the Earth's magnetic field—the "magneto-ionic ducts" as the Americans now call them.

Gehrels picked up both signals as predicted; one arrived in five-hundredths of a second, the other 0·7 second later and from 10 to 30 decibels fainter. Double echoes were frequently observed indicating that more than one path through the exosphere was involved.

During the IGY twenty-eight stations are operating, twenty-three under U.S. direction, three Canadian, and one each in Denmark and New Zealand. At 35 minutes past every hour throughout the period, synchronised electronic clocks will trigger specially designed automatic recorders which will register any incoming signals (either from naturally occurring "whistlers" or

artificially produced signals of the Helliwell type). Groups of paired stations (in North and South hemisphere) are collecting data on the "end-points" of whistlers making two or more hops.

Satellite Watching from Britain

The Russians' satellite arrangements had already been allowed for to some extent by the Royal Society in the planning of the British IGY activities. An Artificial Satellite Sub-committee has been in existence for some time. A circumpolar orbit, such as the one now announced carrying the Russian satellite over Britain, was expected.

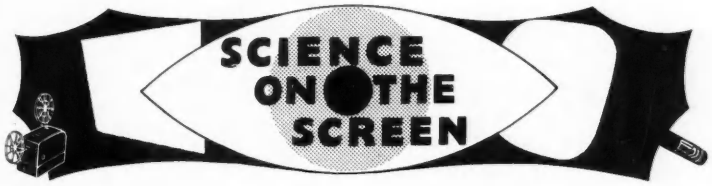
The Jodrell Bank giant radio-telescope should be able to track the American satellite over part of its orbit although this will not reach nearer Britain than 40°N. No doubt this instrument will also track the much closer passage of the Russian satellite—as observatories with smaller instruments (either visual or radio) may also wish to do. In addition, amateurs both of radio and astronomy will have a chance now to watch for an artificial satellite. Arrangements have already been made for satellite observations to be conducted from Ibadan, Nigeria (one of the United Kingdom territories over which it has been known for some time that the American satellite will pass).

Of particular interest are the Royal Society's plans for making use of the passage of artificial satellites to study the ionosphere. "Studies of the effect of the ionosphere on transmission of (satellite) radio signals . . . will give information about irregularities in the ionosphere (and their variation with height) and are complementary to the measurements of ionospheric drift using the scintillation of radio stars. Equipment for this purpose has been developed by a British firm for the Royal Aircraft Establishment, Farnborough, and will be operated for the satellite programme, probably at Lasham aerodrome in Hampshire and at Ibadan. . . ." (p. 51, *The U.K. Contribution to the IGY 1957–8*, 10*s*. from the Royal Society.)

There was a meeting of the Artificial Satellite Sub-committee at the beginning of August to consider what further steps were desirable now that the Russian satellite plans are available. Its findings will be made known in due course.

Tracking Artificial Satellites

At the U.P. Observatory at Nainital, a station will be set up to track optically the artificial satellites that are proposed to be launched by the U.S.A. and the U.S.S.R. This station will be a part of the world network of precision optical tracking-stations. One of the specially developed Nunn-Baker Schmidt cameras is to be given by the Smithsonian Institute, Washington. Dr. J. A. Hynek, Associate Director of the Smithsonian Institute and Director of the optical tracking programme, went to India early in June to discuss this problem with the Indian National Committee and with Dr Vainu Bappu, Chief Astronomer of the observatory at Nainital.



Television

July 11 was the occasion of the eighth and final television broadcast in the Associated-Rediffusion schools science series, "A Year of Observation", specifically devoted to explaining to schoolchildren the meaning and purpose of the International Geophysical Year. Scripted and directed by J. Frankau, with the aid of a scientific adviser, this broadcast formed a fitting conclusion to an admirably organised series to which many authoritative scientists have contributed. Undoubtedly the whole series must have achieved its original purpose of stimulating and interesting the young, and certainly much care and thought has gone into its total conception and structure.

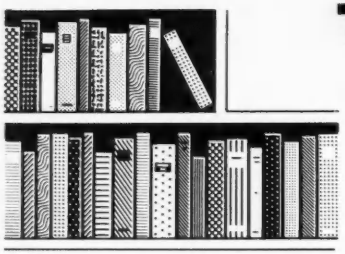
It was indeed right and fitting that the concluding broadcast should have been devoted to "Solar Influence", in so far as the Sun is the prime moving power behind most of the forces being studied in the IGY. In effect, the broadcast was an illustrated lecture, given most ably by Dr M. A. Ellison, of Edinburgh, with interpolated leading questions and competent recapitulations from R. Kyle.

The two main themes were sun-spot activity and solar flares, and as a result the content was not overloaded. As is now becoming usual in such broadcasts, there was excellent use of very clear animated diagrams illustrating, in this particular instance, the various radiations associated with solar flares. To rouse the interest of youth, attention was concentrated on radio fade-out and radio black-out, with topical allusions to recent scares and alarums as to a supposed missing submarine involved in a sun-spot radio black-out. Incidentally, a preview was given of an interesting working model, intended for the South Kensington Science Museum, which illustrated the formation of the aurora.

In almost the whole of the half-hour, Dr Ellison was particularly sympathetic and encouraging to his young listeners (we fervently hope that there were many, although we have no statistics yet). The single weakness in exposition was an over-sophisticated account of cosmic rays, which was certainly above the average schoolboy or schoolgirl, even the competent sixth-former. But, this apart, the discourse was admirable in every respect. From the pedagogic aspect the broadcast probably achieved success, and to this three details of organisation contributed. First was the fact that subtitle captions (such as "Solar Flares") were superimposed on to the picture during the discourse by the speaker. Secondly, the leading questions were aptly interpolated just at the right places; and thirdly, after each natural division of subject R. Kyle gave a competent recapitulation of the preceding subject-matter. This is all very good teaching technique, as distinct from lecturing. The closing five minutes contained a selection of some of the highlights in the films used earlier in the series, the closing note emphasising the international co-operative character of the IGY project.

It is a matter of regret that all these admirable Associated-Rediffusion programmes should have been radiated only for schoolchildren and thus have reached a relatively meagre audience. Surely they must have been recorded, and in any case film occupied a prominent part. It would really be most advantageous if some evening programme-time could be found for reissuing the broadcasts. Science programmes for the adult are surprisingly few, when one takes into consideration the vital impact of science and technology on our habits and culture. Although these broadcasts were nominally for the young, their authoritative handling and their comprehensive approach were such that they could certainly bear repetition to adults without any loss in prestige to the organisers. Associated-Rediffusion is dependent on sponsoring, but surely sponsors are wise enough to see that anything which attracts audiences to their own particular medium will ultimately repay, even if the particular programmes concerned are completely dissociated from any specific advertising, which indeed they are. S. TOLANSKY

THE BOOKSHELF



A History of Industrial Chemistry

By F. Sherwood Taylor (*London, William Heinemann, 1957, pp. xvi+467, 30s. net*).

The history of technology is a subject still comparatively unexplored, although there are welcome signs of increasing interest in it. Because so much was conveyed by word of mouth from one generation to another, and never committed to writing at all, our knowledge of the organisation of industry in former times is very scanty. This applies as much to the chemical industry as to others, and the present book deliberately makes no direct attempt to trace the history of the men and organisations that shaped the chemical industry, though a good deal of information on this point is implicit in the argument. Instead, the author has concentrated on the underlying principles and has sought, for a period extending from ancient times to the present day, to establish the relationship between the chemical industry and contemporary chemistry. On this basis the work is naturally divided chronologically. The first part of the book, roughly one-third of the total, deals with prescientific chemical industries: glass, ceramics, metallurgy, pharmacy, and dyeing, to mention only a few of the main headings. The remainder of the book deals with the period, roughly speaking the last two hundred years, during which chemistry was knowingly and logically applied to technology.

Within these limits the author is notably successful and the book can be warmly recommended both to those interested in the history of chemistry and to those requiring general background information for the study of the history of chemical technology. For those familiar with Dr Sherwood Taylor's earlier works of a like kind, it is needless to add that the book is clearly written and the material well marshalled. The text, especially that of the first half of the book, is much enhanced by a number of interesting illustrations reproduced from early chemical literature.

This is not a book for the specialist—though there can be few so knowledgeable about the subject that they cannot read it without pleasure and advantage—but for the general reader who is prepared to take a little trouble. The latter will gain a very clear picture of all the main modifications of the composition of matter that man has undertaken since earliest times.

It is sad indeed to have to record that this is Dr Sherwood Taylor's last book, for he died shortly after its completion. Few men have had his talent for the exposition of science, especially chemistry: the particular difficulties of explaining the latter are too well known to need emphasis. This present work, and his earlier books on the history of science, will be read for many years to come.

TREVOR I. WILLIAMS

Operation Grapple

(*London, Ministry of Supply, 60 pp.*)

In spite of dire forewarnings of dangerous fall-out, the British tests of hydrogen weapons held at Christmas Island have been completed without significant fall-out being detected anywhere in the world. In current jargon, these experiments can therefore be classed as "clean".

Before the operation, a booklet was produced entitled "Operation Grapple" and circulated to those taking part in it. In the words of the Task Force Commander, Air Vice-Marshal W. E. Oulton, the booklet is an amateur effort to tell personnel something about megaton weapons and the part each service played in the tests. It is also an attempt to describe the Christmas Islands and their environment. In these aims it succeeds so well that one cannot help but regret that the booklet was not given very much wider circulation. The history of the Christmas Island area makes fascinating reading; the short discussion of nuclear weapons is clear and well written, and the chapter on "The Scientific Experiment" gives an interesting account of the various experimental groups, their support and their tasks. Old campaigners will read with satisfaction the description of the rôles played by the Royal Navy, Merchant Navy, Army, Royal Air Force, and the Royal Marines.

That the men involved in such operations are normal human beings doing a difficult (and often uncomfortable) job required of them by their country, and are not monsters bent on destroying humanity, as some propaganda would have it, is amply demonstrated by the chapter headed "Life on a Desert Island".

The opening paragraph of the Foreword—written by the Rt Hon. Aubrey Jones, M.P., Minister of Supply, reads: "In the absence of international agreement on methods of regulating and limiting nuclear test explosions—and Her Majesty's Government will not cease to pursue every opportunity of securing such agreement—the tests which are to take place shortly in the Pacific are, in the opinion of the Government, essential to the defence of the country and the prevention of global war. They represent in their scope the minimum necessary to ensure that our weapons shall be powerful and effective, and a real deterrent to a potential aggressor."

This is a simple and clear statement of British policy—a policy which was advanced in a most important way by the demonstration to the world at Christmas Islands that Britain possesses megaton weapons which can be used operationally.

E. W. TITTERTON

Industry and Technical Progress

By C. F. Carter and B. R. Williams (*Oxford University Press, 1957, 239 pp., 25s.*)

This is an important and authoritative book which should be read by all who are concerned with scientific research, whether as employers, administrators, or research workers. It is the report of a five-year inquiry on behalf of the British Association (joined later by the Royal Society of Arts and the Nuffield Foundation) who set up a committee "to study the problems of speeding up in industry the application of the results of scientific research". Inquiries were conducted under the direction of Profs. Carter and Williams and their findings are backed by the collective experience of the committee, which included university and industrial scientists, economists and others.

For too long have thoughtless people in this country been saying that much of British industry has no appreciation of scientific advance, and this is usually followed by some simple "solution" of the problem. The authors of this book state: "At the end of the road we are as impressed as we were at the beginning by the immense complexity of the forces impelling or hindering the application in the ordinary business of life of the products of man's scientific ingenuity."

On the matter of communicating research results to industry, I am glad to see that the importance is recognised of the scientific middleman—the research association, the technical journalist, the salesman with a scientific background, the travelling advisory officer—as is also the place of the trade journal as a source of technical information, especially in small firms.

A very useful chapter establishes the principle that industrial research is a management technique which for efficient use must be related to other management problems of the firm. The good management of research and development is shown to be of critical importance in the rapid application of science and technology.

Chapter 8 reviews the principles affecting the selection of research projects and should be read by all research directors. Industry is interested in research which will earn profits. There

Modern Computing Methods

Numerical methods are required in all branches of science and the techniques are generally independent of the source of the problem. The methods discussed in this book, though based on lectures in a course dealing with electrical engineering, will therefore have general application. Bibliography. **10s. 6d.** (*post 4d.*)

Research in 1956

The latest additions to the annual series of reports from the specialised organisations of the D.S.I.R. Illustrated.

Chemistry Research	**4s.** (*post 3d.*)
Radio Research	**3s.** (*post 2d.*)
Mechanical Engineering Research	**4s.** (*post 3d.*)

HMSO

from Government Bookshops or through any bookseller

STATISTICS

Introduction to Statistical Analysis

W. J. Dixon and F. J. Massey

The second revised edition of this introductory text includes a new chapter on probability. Classical and modern techniques are studied and compared. The understanding and uses of these techniques are emphasized, rather than their mathematical development, and no knowledge of the calculus is required. Examples are taken from chemistry, agriculture, engineering, medical research and psychology.

Already published *450 pages* *45s*

Introduction to Statistical Reasoning

P. J. McCarthy

A more elementary treatment of the subject than the previous book, this text stresses the concepts of statistical reasoning rather than a wide variety of techniques. The basic ideas are presented as soundly and rigorously as possible, assuming that the student has had little mathematical training.

October 1957 *425 pages* *43s*

McGRAW-HILL

★ READY IMMEDIATELY ★

Through Alchemy to Chemistry

by JOHN READ, F.R.S.

Subtitled "A Procession of Ideas and Personalities", Professor Read's rich and absorbing narrative, appealing equally to pupil and teacher, to layman and specialist, ranges from the conceptions of ancient civilisations, through the long age of alchemy, to the benzene ring, electrons, atomic structure, and space chemistry.

Very fully illustrated. 18*s.* 6*d. net*

★ NOW READY ★

THE FIRST THREE

Scientific American

BOOKS

The editors of the *Scientific American* have prepared a series of books on specific areas of science in which work in progress is pushing out the frontiers of human knowledge at a rapid rate. The books are based on contemporary articles from the magazine written in non-technical English by leading scientists from all over the world and newly edited to give their readers (including scientists specialising in other fields) an understanding of what is interesting and important in modern research in the areas covered.

The Physics and Chemistry of Life

18 articles on life as a physical process. For example: Prof. George Wald on *The Origin of Life*, Linus Pauling, Robert B. Corey and Roger Hayward on *The Structure of Proteins*, Prof. C. H. Waddington on *Cell Differentiation*, Prof. Bernhard Katz on *Nerve Impulse*. 282 *pages.* 13*s.* 6*d. net*

20th Century Bestiary

24 articles—"a sampling of the curious and wonderful inventions of life"—from Tinbergen on *The Courtship of Animals* to David Lack on *Darwin's Finches*, from *The Language of Bees* to *Bird Aerodynamics*. 252 *pages.* 13*s.* 6*d. net*

Automatic Control

12 articles, including *Feedback* by Prof. Arnold Tustin, *An Automatic Chemical Plant* by Eugene Ayres, *Information Machines* by Louis N. Ridenour, *An Imitation of Life* by W. Grey Walter. 158 *pages.* 10*s.* 6*d. net*

BELL

is too much confusion in the minds of many scientists between interesting research and industrially useful research which this chapter will help to expel. "There is still great need for the inspiration of genius, but much routine discovery and improvement waits simply for the investment of sufficient resources."

There follow fairly full analyses of the need for and the employment of trained men and women, and the effect of the organisation of industries on the rate at which science is applied. On the subject of money to finance development, it is concluded "that the effect of high taxation on the incentive to undertake product or process development is not a direct one . . . but we think that the *indirect* disincentive effects of high taxation are important".

The effect of size and spread of markets on technical innovation and the environment of industry which influences the attitude to new developments or processes are examined. In this latter connexion, the authors do not find evidence that "restrictive practices" by either management or workers are a serious hindrance to technical advance.

The characteristics of the technically progressive firm are next examined and this study is followed by a statement of the requirements of a progressive economy, and this suggests that the gap between good and bad firms tends to widen. "It will take much ingenuity by industry and government to break up the crust of habit and to divert lively and able minds from the places where change is most likely to those where it is most needed."

The report has three appendices: The Science and Industry Committee, the Case Studies, and Examples from the Case Studies. E. S. HISCOCKS

Left-handedness: Laterality Characteristics and Their Educational Implications

By Margaret M. Clark (*London, University of London Press Ltd, 1957, xvii +212 pp., Price 15s.*)

The subject of handedness continues to attract the attention of educators and psychologists. The present volume is timely because it supplies a much-needed evaluation of numerous previous studies and reports an original investigation of the laterality traits of a group of normal, unselected children. The subject-matter is compactly presented in 21 chapters and 29 tables. The treatment is factual and objective; but it reflects the vital interest of the author in the human aspects of the problem of left-handedness as it confronts parents and teachers. This enhances the scientific and educational significance of Dr Clark's work. She hopes for a better understanding of left-handedness, which in her own words "may even lead to a more tolerant attitude towards the 'sinister minority', to which the author herself belongs."

The origins and nature of handedness are reviewed in the first half of the present volume. Brief critical comments are made on a wide range of topics, including the following: handedness as related to eye dominance and environmental factors; left-handedness as an acquired form of rebellious negativism, and as a mode of mendelian inheritance; the connexion of brain dominance to speech and laterality; the effect of changed handedness on stuttering; the relations between ambidexterity and retarded speech. Separate chapters deal with the measurement of handedness and methods for the determination of eye dominance and crossed laterality.

Laterality characteristics play a rôle in reading difficulties. But it is in the field of writing that left-handedness brings forth its most varied manifestations, some benign, but others of import for teaching and mental hygiene. Emphasis is placed on the fact that "writing with the left hand is not the same as writing with the right, with only a change of hand". Many faults of hand posture can be readily prevented in their early stages by suitable guidance. The same holds true for mirror script.

The discussion of the theories and the patterns of laterality lays the basis for the second half of the volume, which reports an experimental study of the laterality characteristics of 330 Glasgow children, 162 boys and 168 girls from eleven to twelve years of age. The group was entirely unselected with regard to hand preference. This fact gives the analysed data added significance. Each child was individually examined by a battery of 18 tests covering the dextrality and sinistrality of handedness, footedness, earedness, and eyedness. Interview data were also gathered from parents and pupils.

Although this experimental investigation was limited to a narrow age zone at the threshold of adolescence, it demonstrated that handedness, whether right- or left-, is not a simple unitary factor but varies markedly from individual to individual, and varies with different activities of one and the same person. Preferred handedness and footedness tend to be associated; likewise, the listening ear and the preferred eye. Whether true ambidexterity is either frequent or desirable is left in doubt. Emotional and interpersonal factors may colour the developmental history of a resistant left-handed child, and he may suffer from enforced use of the subordinate hand; but the results of the Glasgow study should reassure parents that left-handed pupils have learned to read and to write without emotional upsets. The study infers that "no essential difference was apparent between left-handers and right-handers except for their use of a different hand". The author holds that in view of current misconceptions and attitudes, that "it is imperative that the same attention be given to teaching left-handers to write with the left hand as is devoted to right-handers".

Further research is clearly needed to define methods for the early detection of unsuspected cases of innate and constitutional left-handedness. This demands developmental observation of the symmetries and asymmetries of postural and of eye-handed behaviour in early infancy and during the preschool years. Handedness is not a simple trait which is formed at one time, once and for all. It is a focal symptom of the current stage of a growing organism. It takes fluctuating but progressive form and the laterality characteristics are in great measure established in the first five years of life.

By calling attention to the varied factors which enter into the phenomenon of left-handedness, the reader is made aware of both the personal and the educational implications of the subject. This leads to better understanding on the part of all concerned—be they left- or right-handers, parents, pupils, teachers. In short, we have another very valuable addition to The Publications of the Scottish Council for Research in Education. ARNOLD GESELL

The Indian Ephemeris and Nautical Almanac for the Year 1958

Prepared by the Nautical Almanac Section of the Regional Meteorological Centre, Alipore, Calcutta (*published by the Manager of Publications for the Government of India; pp. xviii+392 cloth bound, 7×10 inches; price 12 Rupees*).

This volume, the first issue of the "Indian Ephemeris", marks an important step in the development of modern astronomy in India. It is a worthy tribute to the enthusiasm and persistence of the late Prof. M. N. Saha, F.R.S., to whom the original proposal and a large part of the preliminary organisation and planning were due.

The initial impetus for the introduction of a separate "Ephemeris" arose from the necessity to reform and unify the many different calendarial systems in use in India. It is therefore no surprise to find that no fewer than forty-three pages are devoted to the Indian Calendar, giving full details of the Reformed Calendar of India. In other respects the Ephemeris follows very closely the models adopted by the other national ephemerides, particularly the "American Ephemeris". The fundamental calculations have for long been shared between the ephemeris offices of France, Germany, Spain, United Kingdom, U.S.A., and U.S.S.R., and these have been made readily available for the preparation of this volume. The work of preparation has thus largely been concerned with compilation, presentation and printing: these have been done excellently under the competent guidance and supervision of Sri N. C. Lahiri.

The most interesting feature of the volume is the brief history of Indian astronomy to A.D. 1150, and the references to the low standard of practical

A Dictionary of Scientific Terms

I. F. HENDERSON

W. D. HENDERSON

Revised by J. H. KENNETH

The new edition of this famous dictionary now gives the pronunciation, derivation, and definition of over 14,000 terms in biology, botany, zoology, anatomy, cytology, genetics, embryology, and physiology.

SIXTH EDITION—32*s.* net

Oliver & Boyd

University Correspondence College

Founder: William Briggs, LL.D., D.C.L., M.A., B.Sc.
Principal: Cecil Briggs, M.A., *M.C.*
Vice-Principal: Arnold Saxelbye, M.A.Camb., B.A.Lond.
Arts Director: P. G. Hall, M.A.Camb.
Science Director: George Walker, Ph.D.Camb., M.Sc.Syd.

Science Courses

- U.C.C. provides Courses of Study in **Biology, Botany, Chemistry, Physics, Geography, Geology, Mathematics, Zoology.** Full tuition is given for the **General Certificate of Education** (all Levels) London, Oxford, Cambridge, Northern Universities, etc., **London University Intermediate Science,** and **Final B.Sc.** (General and Special), **Engineering Joint Board Preliminary, Pharmaceutical Society Intermediate,** and other examinations.
- The College, founded 1887, is an Educational Trust with a staff of highly qualified Tutors, and the moderate fees may be paid by instalments if desired.

★ **PROSPECTUS** post free from the Registrar,
48 Burlington House, CAMBRIDGE

Schools of Psychoanalytic Thought [42s.]

RUTH L. MUNROE

This book provides the psychologist and the general reader with the most comprehensive account available in one volume of the major schools of psychoanalysis. Dr. Munroe, who is Professor of Clinical Psychology at the City College of New York, also discusses their relative values.

Man's Journey Through Time [30s.]

L. S. PALMER

In this book Professor Palmer describes in detail modern methods of dating and correlating the remains of primitive man, and he discusses the application of these methods to recent discoveries. The consequences of different rates of development are also assessed. *Illustrated.*

The Prehistory of Africa [63s.]

H. ALIMEN

The primary importance of Africa in the history of man is clearly shown in this book. Professor Alimen outlines the results of the latest research, and covers the ancient geography of Africa, its geology, its climate in former times, its fossils and stone implements, and its primitive cultures. *Illustrated.*

Reason and Chance in Scientific Discovery [30s.]

R. TATON

In this work Dr. Taton examines the relative roles of active purpose and chance in the processes of scientific discovery, and gives us a clear insight into the workings of the creative mind. *Illustrated.*

Hutchinson

Scientific, Technical and Medical Publications

astronomical knowledge, very largely used for astrological purposes in recent years. Its immediate purpose will have been achieved when its influence on the many local almanacs ("panchangs") results in the use of accurate astronomical data and predictions. But it is much to be hoped that its introduction will inspire serious astronomical work in India.

There are therefore special reasons for the inauguration of a new national ephemeris at a time when there is a strong tendency towards unification. As from the editions for 1960 the British and American ephemerides will be completely unified although they will continue as separate publications; both the German ephemerides will be discontinued in favour of the unified British-American editions; and it is hoped that other national ephemerides (including the one reviewed here) will take advantage of the arrangements now available for the photographic reproduction of the whole, or parts of, the unified edition.

D. H. SADLER

The Sun

By G. Abetti (*London, Faber and Faber, 1957, 336 pp., with 147 plates and 97 diagrams in text, 63s. Translated from the Italian by J. B. Sidgwick.*)

Prof. Giorgio Abetti is the successor to a long line of eminent Italian astronomers—including such famous names as Galileo and Secchi—who have contributed notably to our knowledge of the Sun. For many years (1921–52) he was director of the Astrophysical Observatory at Arcetri near Florence.

The present work was first published in 1934 and revised twenty years later, and it is the 1954 edition which is now translated into English by J. B. Sidgwick, with much new material added to take account of the most recent developments.

Abetti's love for the history of science—to which he has also contributed a number of valuable writings—is evident in the introduction, where he discusses the early solar work of Galileo and Scheiner. There follow chapters devoted to the instruments of solar observation, sun-spots—their distribution and periodicity—and the Sun under spectroscopic observation. Sections dealing with such subjects as the magnetic fields and classification of sun-spots, the spectroscopic determination of the solar rotation period, the Sun's radiation and temperature, are particularly full and illuminating. Much of this information cannot readily be found elsewhere.

As is inevitable in the revision of a previous volume, the treatment of the subject-matter and the general emphasis tend to reflect the outlook of an earlier period. In such a comprehensive account one could wish, for example, for a fuller treatment than the single chapter which deals with solar activity and its influence upon the Earth. This is a subject of fundamental and growing importance, as is indicated by the wide range of such studies being undertaken during the International Geophysical Year.

The illustrations throughout are excellent, and it is a great pleasure to have for reference so many of the best spectra and so many fine photographs of instruments, chromosphere, and prominences. Here is a book that can confidently be recommended to the general reader and to the student of astronomy, as a sound and detailed introduction to solar research and to the many fascinating problems which await solution.

M. A. ELLISON

De Motu Cordis

William Harvey, translated from the Latin by Kenneth Franklin (*Oxford, Blackwell, 1957, pp. xii+210, 17s. 6d.*

In a recent issue of DISCOVERY (June 1957, p. 228) two illustrations were reproduced from my book, "William Harvey, his Life and Time, his Discoveries and Method", published simultaneously in French and English (Sedes, Paris; Hutchinson, London). After many years spent in studying the original Latin texts of William Harvey and translating these into French, both as articles for the medical press and for my recent book, circumstances have now brought to my notice a beautiful work, magnificently presented in the best traditions of English publishing. This is the new English translation of "De Motu Cordis . . ." by Prof. Kenneth Franklin, F.R.S.

I am not, perhaps, completely qualified by my knowledge, alas! rather limited, of all the delicate shades of meaning and niceties of the English language to appreciate this translation and to convey my appreciation to others. But I believe that I have learnt enough of the language during the last three years when I have had occasion to use it—while at the same time being familiar with Latin from early childhood—to enable me to confront the two languages and tell readers of DISCOVERY what has been suggested to me by the study which I have just completed.

This new translation seems to me greatly superior to that of Robert Willis in 1847, which, though extremely thorough, gave me the impression that certain nuances of Harvey's Latin thought had escaped the translator of that date, as, in many instances, they have escaped the French translators of the "De Motu . . ." of the 1880 period, and even of the present day! This failing is due, I believe, to their being insufficiently conversant with the Latin tongue. Indeed, it was because of this that, three years ago, I myself undertook to translate the "Exercitationes duae Anatomicae" of 1649, the supplement to the "Exercitatio" of 1628, keeping as close as possible to the original Latin. This enabled me to show their importance to the exact understanding of Harvey's true thought, even though they had been pronounced "less clear" and "a mass of unprofitable speculation" (D'Arcy Power: "William Harvey" in "Masters of Medicine", 1897, p. 227). This is probably why more recent translators, such as J. J. Izquierdo, of Mexico, in 1936, and Ch. Laubry, of Paris, in 1950, only translated the "Exercitatio" of 1628.

These pronouncements and attitudes are, to my way of thinking, pure heresies, and that is why—I say this directly to Dr Franklin—I look to him to give us, in the near future, an English translation of these two "Exercitationes" which will complete the memorable work on Harvey's thought begun with his new translation of the first "De Motu . . .".

Regarding the translation itself, I consider that Dr Franklin has followed Harvey's original Latin much more closely than Willis. He has therefore better expressed the first views of the great discoverer, who remained, as he himself declared in the "Exercitatio", sometimes hesitant about certain interpretations for which, in 1628, he lacked the conclusions of some experiments he was planning at the time. It was exactly twenty-one years later that he expressed, in two new "Exercitationes", certain precisions and hypotheses which he considered better founded after this long period of observation and meditation devoted to them.

Once again I sincerely hope that Dr Franklin will give us these in an English translation of as high a degree of excellence as that of the "De Motu . . ." which has just been published. In the meantime, the English reader is now provided with an invaluable document to approach that prodigious gestation of the ideas of a mind which, from 1603 to 1649, wished to leave none of what it had so well established "geographically" unknown or hypothetical. "Hac data via", as Harvey wrote.

The only reproach I might feel called upon to make to Dr Franklin would be if he told me that he intended to stop his work at this point.

While waiting for his new translation of the "Exercitationes duae . . .", it seems to me that every scientific library, whether public or private, which is anxious to possess a completely up-to-date documentation, must find a place for Dr Franklin's English version of the "De Motu . . ." but must also keep a place for the future translation which, I insist, will complete his work.

L. CHAUVOIS

Brief Notes

The U.S. Information Services at the American Embassy, London, W.1, are prepared to send copies of three publications to interested people. These are on the use of aerial photography in President Eisenhower's Mutual Inspection Plan. Details concerning true-vertical, trimetrogon, and forward-oblique aerial techniques are given, and the publications also deal with camouflage detection, mosaics, and other details.

FAR AND NEAR

Aborigines Like Storks

In an area of salt-marshes and sand-hills in the south-west of central Australia, a patrol led by Mr E. C. Evans recently discovered two groups of nomadic aborigines. They live on small hopping rats, lizards and mice, and wear only a necklet and belt of human hair.

The Darwin correspondent of *The Times* also reports some scientific studies being made to discover why certain Australian aborigines often stand on one leg to rest, like birds of the stork family. Dr S. H. Scougall is leading a research party into Arnhem Land to investigate the phenomenon; one theory to explain it is that the one-legged stance was a position of rest which was yet alert and defensive. Dr Scougall hopes to train white men to stand in the same way, so that an electromiographic study can be made.

New Polio Vaccine

The WHO expert committee on poliomyelitis, at present meeting in Geneva, has come out strongly in favour of large-scale trials of a new polio vaccine prepared from a living virus which has been "attenuated" so that it is no longer capable of causing the disease although it may be expected to provide lasting protection against it. The live-virus vaccine can be given orally, instead of being injected. The experts are satisfied that preliminary trials of this vaccine carried out by several different research teams have failed to reveal any signs of illness or other harmful effects either in the persons vaccinated or in members of their families. They consider, therefore, that the vaccine may now safely be given larger-scale trials among the population. At the same time, the WHO experts do not suggest that this vaccine should displace the Salk type of killed-virus vaccine in those countries where it is now being used or is about to be used. They believe rather that the new vaccine should be an adjunct to the present vaccine, though it might eventually replace it if that is found desirable, or be a substitute for it where the use of the Salk vaccine is not feasible.

If the proposed trials of the live-virus vaccine prove successful, it may be hoped, according to the WHO committee, that the immunity it provides will be reliable and long-lasting, and may result in the elimination, or at least in a substantial reduction of the virulent strains of polio virus at present in circulation. In the WHO experts' opinion, the present killed-virus vaccine is not able to achieve this kind of result. The committee emphasises, however, that the most stringent precautions should surround the proposed trials of the new vaccine. In order to prove its complete harmlessness, it should first be given to limited numbers of selected groups of persons. Furthermore, the properties of the attenuated strains of virus used in the vaccine should be measured in a number of different laboratories. It is recommended also that the trials be done on a voluntary basis and with the approval of the local authorities concerned.

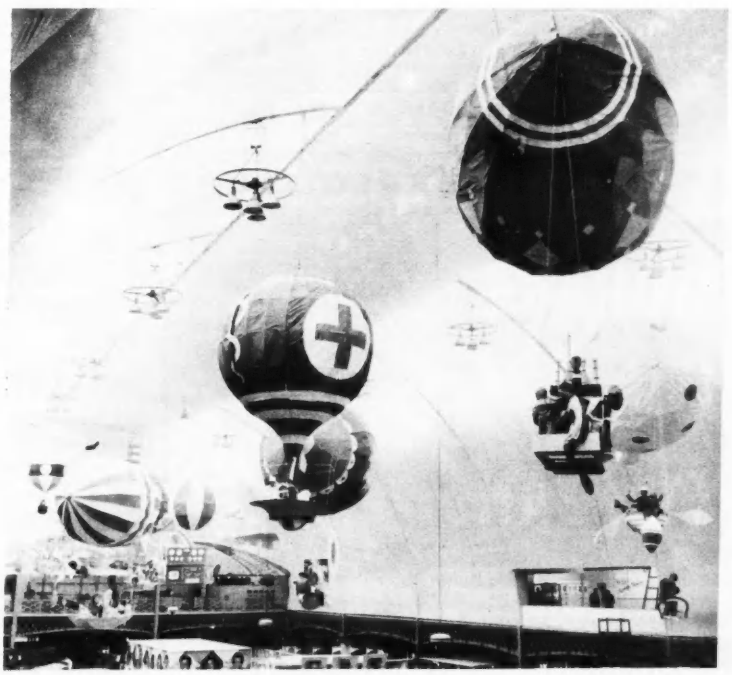
The committee stresses that the object of the proposed trials of live-virus vaccine and the need for carrying them out are based on the belief that they may go far in further reducing the prevalence of poliomyelitis in the world.

Glaciers for Hydro-electric Power

The famous glacier on Mont Blanc, known to tourists as the Mer de Glace, is soon to be harnessed to provide hydro-electric power for France. The scenic beauties of the region will remain unspoiled, since all constructions are to be concealed underground.

According to UNESCO, the river flowing beneath the glacier will be tapped at an altitude of 4700 feet. The water will be drawn off through a tunnel over a mile long to a point where high-pressure pipes will carry it down a sharp drop of about 1200 feet to an underground power-station in the valley of Chamonix.

A similar scheme has been worked out for the glacier of Argentière, on the other side of Mont Blanc. Here the fast-flowing torrent beneath the glacier will be led from a height of over 6500 feet through a series of tunnels twenty-seven miles long to the Emosson basin, on the Franco-Swiss border, where a large dam is to be constructed. From there the water will be channelled to two power-stations on the other side of the Swiss frontier and energy generated will be distributed equitably between France and Switzerland. Electric power produced through this scheme is expected eventually to reach 600 million kilowatts a year.



This year's Hulton's Boys' and Girls' Exhibition at Olympia, the second of its kind, aims once again "to entertain and to inform". Its theme is careers, and when glancing at the exhibits, there is little doubt that careers mean jobs in science and technology for boys. Similar to last year, the Armed Forces, as well as private and nationalised industry, are well represented, and there are certainly crowds of boys and girls eager to learn. The galaxy of space-ships which decorated the ceiling last year has given way to a bunch of balloons copied from models in the Science Museum; each represents, allegorically, one career.

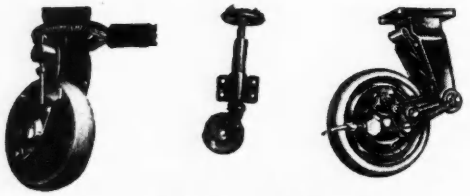
A year ago (DISCOVERY, 1956, p. 400) we commented: "Should this imaginative exhibition become a regular annual event, it will be interesting to watch which scientific profession will be most in demand." There is certainly no change yet; girls are still unwanted for any scientific career—nursing, ballet, and dress-shows are the only attractions for them. Again there is no appeal for young biologists, medical research workers, or social scientists. Will this pattern of exhibits, apparently already hallowed by success, remain constant for all future exhibitions?

Make Light of Weight

AUTOSET

CASTORS

Wheels 2" to 46" diameter
Loads up to 30 tons each



ASK FOR LIST No. 389

ENGINEERS, PATENTEES & SOLE MANUFACTURERS
AUTOSET (PRODUCTION) LTD
ESTABLISHED 1919

75-80 STOUR STREET, BIRMINGHAM 18 *'Phone EDG 1143*

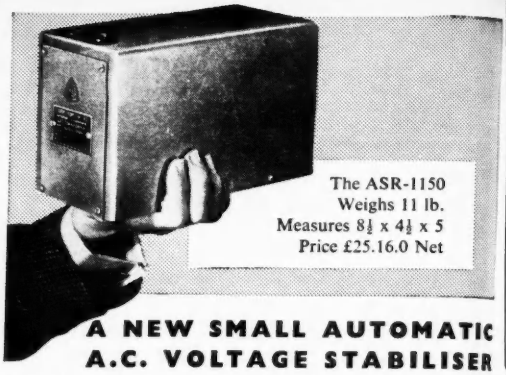
AT/B.26

ANTARCTIC EXPEDITION

During the recent Antarctic expedition Morane Heatsealing Plastic Skin was used for the protection of prints in furnishings supplied to the *S.S. Tottan*—ample proof of the protection given by Morane Heatsealing Plastic Skin. Easily fixed by unskilled labour, this washable, high gloss plastic skin is ideal for Notices, Documents, Book Covers, Charts, Labels, Blueprints, etc., and gives an instantaneous firm bond to paper, cardboard, etc.

SEND FOR FULL DETAILS

MORANE PLASTIC CO. LTD.
21 WOODTHORPE RD. ASHFORD, MIDDX
Tel. Ashford Middx 4016/7



The ASR-1150
Weighs 11 lb.
Measures 8½ x 4½ x 5
Price £25.16.0 Net

A NEW SMALL AUTOMATIC A.C. VOLTAGE STABILISER

This Stabiliser, of the A.C. automatic voltage step-regulator pattern, will handle loads up to over 1 kilowatt—and has an output of 5 Amperes at (usually) 230 volts. A a general rule it weighs only about 1-10th of the so-common "choke-condenser" types offered by many competitive firms. It has no large high-rating capacitors—which fail regularly in "resonated" types of Stabilisers, and which are very expensive to replace.

ASR-1150 is insensitive to changes of mains frequency, works equally well from 0% to 100% load (maximum loading 1150 VA), and has sinusoidal output waveform. The degree of Stabilisation it provides is ample for very many purposes.

Complete details of our entire range of Regulators, of which there are many patterns ranging from 200 VA to about 30 kVA (single-phase) are given in our new 32-page Automatic Voltage Regulator Catalogue (5-574) which will be sent at once against your written request.

Claude Lyons Ltd.
STABILISER DIVISION · WARE ROAD · HODDESDON HERTS
CL 34

$$\frac{1{\cdot}008^{3\cdot4} \times \sqrt[3]{63} \times 4000}{6 \times \sqrt[5]{260000} \times 42^{1\cdot32}} = 0{\cdot}2495$$

Pocket Size but as accurate as a 5 ft. 6 in. slide-rule

The Otis King Calculator, with its 66-in. scales, is more useful than any ordinary slide-rule. Problems like the above—and, of course, others less complicated—are solved in a few seconds: accurate results to four or five significant figures can be read.

Yet the Otis King Calculator is handy enough and sturdy enough to be carried regularly in your pocket. Collapsed, it measures only 6 in. × 1¼ in. It is strongly made in metal with almost everlasting plastic-coated scales. And it costs (in U.K.) only 57*s.* 6*d.* post free.

If you have any use for this amazing little instrument send the form below today. Unless you are completely satisfied, your money will be refunded in full. *Fully descriptive leaflet sent free on request to* Carbic Ltd., 54 Dundonald Road, London, S.W.19.

The OTIS KING Pocket Calculator

Send this form today

To Carbic Ltd. (Dept. D), 54 Dundonald Rd., London, S.W.19.
Herewith cheque for 57*s.* 6*d.* Please send me one Otis King Calculator on your guarantee that if I return it within 7 days, you will refund the money in full.

Name .....
(BLOCK LETTERS, PLEASE)

Address .....

.....

.....

Classified Advertisements

OFFICIAL APPOINTMENTS

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts.

The posts are divided between following main groups and subjects: (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects, and (*e*) Miscellaneous (including e.g. Geology, Library, and Technical Information Services).

Age Limits: For Experimental Officers, at least 26 and under 31 on December 31, 1957; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1957. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specialised qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1957 may be admitted provisionally. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Salary (London):

Experimental Officer. Minimum £925 (women £853); Men's scale maximum £1135.

Assistant Experimental Officer. Starting pay £365 (at 18) up to £655 (women £632) at 26; Men's scale maximum £805. These salary scales are being increased by approximately 5%. Women's scales are being raised to reach equality with men's by 1961. Somewhat lower outside London. Promotion prospects.

Opportunities for further education.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/57.

Interview Boards arranged at intervals, as required. Early application is advised.

LABORATORY SUPERINTENDENT required by NIGERIA NORTHERN REGION Medical Department for tour of 12/24 months in first instance, either (*a*) with prospect of pensionable employment in salary scale (including inducement addition) £750 rising to £1284 a year, or (*b*) on temporary terms in salary scale (including inducement addition) £810 rising to £1386 a year plus gratuity at rate of £100–£150 a year. Commencing salary according to experience. Clothing allowance £45. Free passages for officer and wife. Assistance towards children's passages and maintenance grant up to £288 annually. Liberal leave on full salary. Candidates must be A.I.M.L.T. and must be experienced in all branches of pathology, bacteriology, and biochemistry. Duties include management of laboratory staff and stores and demonstration of laboratory methods. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications, and experience, quoting M3/44167/DI.

LABORATORY TECHNICIAN (PHYSIOLOGIST) MALE OR FEMALE required by EAST AFRICA HIGH COMMISSION for East African Veterinary Research Organisation for tour of 30/36 months either (*a*) on probation for permanency with free pension or contributory Superannuation Scheme at officer's option, or (*b*) on contract with gratuity at rate 13½% of total substantive salary drawn. Salary scale (including inducement pay) £846 rising to £1341 a year. Commencing salary according to experience. Outfit allowance £30. Free passages. Liberal leave on full salary. Candidates, aged 24–40, must possess A.I.M.L.T. preferably in Bacteriology, or equivalent, and have good practical knowledge of psysiological laboratory technology. Female candidates must be SINGLE. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications, and experience, and quote M3/43369/DI.

APPLICATIONS are invited for pensionable posts as

EXAMINERS
in the
PATENT OFFICE

to undertake the official scientific, technical, and legal work in connexion with Patent applications.

Age at least 21 and under 35 years on January 1, 1957, with extension for regular Forces' service.

Candidates must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptionally, candidates otherwise qualified by high professional attainments will be considered.

Starting pay for five-day week of 42 hours in London between £605 and £1120 (men), according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1345. This salary scale is being increased by approximately 5%. Women's pay above £605 slightly lower but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner rising to £2000 (under review) and reasonable expectation of further promotion to Principal Examiner.

Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S128/57 and stating date of birth.

Interview Boards will sit at intervals, as required. Early application is advised.

WIRELESS OPERATOR MECHANICS required by FALKLAND ISLANDS DEPENDENCIES SURVEY for service either (A) at isolated British Bases in the Antarctic, or (B) at the W/T Station Port Stanley. Commencing salary according to age in scales set out below. Candidates, preferably single, must be able to transmit and receive morse at 20 words a minute and be capable elementary maintenance wireless transmitting and receiving equipment. Salary scale (A) £330 rising to £420 a year with all found, including clothing and canteen stores. Keen young men between 20 and 30 years required, of good education, and high physical standard, with genuine interest in polar research and travel and willing to spend 30 months under conditions testing character and resource. Salary scale (B) (including Expatriation Pay) £400 rising to £505 a year. Gratuity £70 a year. Full board accommodation obtainable at about £14 a month. Three-year tour. Candidates, preferably with P.M.G. 2nd Class Cert., should be between 20 and 35 years of age. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications, and experience, and quote for post (A) M2C/42227/DI, and for post (B) M2C/42361/DI.

ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts.

Age at least 17½ and under 26 years of age on January 1, 1957, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian

scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:

(*i*) Engineering and physical sciences.
(*ii*) Chemistry, bio-chemistry, and metallurgy.
(*iii*) Biological Sciences.
(*iv*) General (including geology, meteorology, general work ranging over two or more groups (*i*) to (*iii*) and highly skilled work in laboratory crafts such as glass-blowing).

Starting pay £340 (at 18) up to £460 (women £431) at 25. Men's scale maximum £635. Women's scale being raised to reach equality with men's by 1961. Somewhat less in provinces. Opportunities for promotion and for further education. Five-day week, generally.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S59/57.

Interview Boards sit at intervals, as required. Early application is advised.

GOVERNMENT OF SARAWAK

GEOLOGIST

Qualifications: 1st or 2nd Class (Upper Division) Honours Geology degree. Post graduate experience an advantage.

Age limit: 40 years.

Duties: Mostly field mapping. One of the main objects being a search for mineral wealth and the testing of deposits.

Officer appointed will be liable for service anywhere in Sarawak, North Borneo, and the State of Brunei.

Terms of appointment: On probation to the permanent establishment with emoluments in the scale £1344–£2324 p.a. Outfit allowance. Education allowance. Quarters provided at rental. Free passages. Free medical attention. Generous leave. No personal income-tax at present.

Apply to Director of Recruitment, Colonial Office, London, S.W.1. State age, qualifications and experience. Quote BCD 105/127/01.

APPOINTMENTS VACANT

THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC CO. LTD, NORTH WEMBLEY, MIDDLESEX, have the following vacancies for graduates:

(*a*) MATHEMATICIAN, OR PHYSICIST, OR ELECTRICAL ENGINEER interested in Mathematics, to study the fundamentals of microwave valves from the theoretical and experimental point of view.

(*b*) ENGINEERS who are keen to do experimental work in the fields of High Frequency Heating and Industrial Space Heating.

(*c*) ENGINEER with mechanical and electrical experience, and with a keen interest in precision welding of light engineering products, for development of equipment and techniques. Experience of engineering drawing, work handling methods, and some general experience of metal joining would be an advantage.

(*d*) PHYSICIST OR ELECTRICAL ENGINEER for research on the use of Ferrites and Ferroelectric Devices at microwave frequencies.

(*e*) PHYSICIST OR ELECTRICAL ENGINEER to work on new types of Telecommunications Line Systems. This could involve the application of transistors and the use of new techniques in the design of such systems.

Candidates for these posts, which offer considerable opportunities of advancement should be not older than 30 years of age and should preferably hold good honours degrees.

Apply in writing to the Staff Manager (Ref. RLO/132), giving full particulars of experience, qualifications and age.

CRYSTAL ANALYSIS

THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC CO., LTD., North Wembley, Middlesex,

have a vacancy for a PHYSICIST or CHEMIST to assist with a programme of work in the field of CRYSTAL ANALYSIS, with particular emphasis on magnetic and ferro-electric materials. Experience in x-ray diffraction methods is desirable, but not essential.

This position offers considerable opportunity of advancement to a graduate who is interested in this field of work.

Candidates under 26 years of age must have completed or be exempt from National Service.

Apply in writing, to the Staff Manager (Ref. RLO/148), giving full particulars of experience, qualifications and age.

FOR SALE

BOUND VOLUMES of DISCOVERY 1951–56 in immaculate condition. Prices—25*s*. for 1956, others at 20*s*. each. Davies, 196 Llandaff Road, Cardiff.

LECTURES AND COURSES

UNIVERSITY OF LONDON

DEPARTMENT OF EXTRA-MURAL STUDIES

UNIVERSITY EXTENSION COURSES IN SCIENCE

Beginning in Autumn 1957

1. The Philosophy of Science
   24 lectures (for graduates) at the City Literary Institute, Drury Lane, W.C.2.
2. Recent Advances in Plant Physiology
   10 lectures (for graduates) at Chelsea Physic Garden, Royal Hospital Road, S.W.3.
3. The Rise of Technology
   12 lectures at the Science Museum, South Kensington.
4. Scientific Aspects of Air Pollution
   12 lectures at The Huxley Building, Imperial College, South Kensington.
5. Mammals in Britain
   12 lectures at the Linnean Society's Meeting Room, Burlington House, Piccadilly.

Full particulars of these courses and of a wide range of others intended both for those with scientific knowledge and those who wish to gain some knowledge and understanding of science can be obtained from The Deputy Director (Extension D), Department of Extra-Mural Studies, University of London, Senate House, W.C.1.

FARADAY HOUSE
ELECTRICAL ENGINEERING COLLEGE

A THREE-YEAR COURSE, commencing each term, in Electrical Engineering to qualify for Associate of Faraday House and Graduate of the Institution of Electrical Engineers, followed by one year's practical training in Industry to qualify for the Diploma of Faraday House. For Prospectus apply to Department "E", Faraday House Electrical Engineering College, 66 Southampton Row, London, W.C.1.

SOCIETIES

THE BRITISH
INTERPLANETARY SOCIETY

12 Bessborough Gardens,
London, S.W.1

MEMBERSHIP and Fellowship is open to all interested in space-flight, rocket engineering and astronomy.

Full particulars of membership, together with a free copy of the Society's Journal and programme of lectures in London and many provincial towns, will be sent on request.

Printed and Published in Great Britain by Jarrold & Sons Ltd, Norwich *Editorial Office: 244 High Holborn, W.C.1*

REKAB
INSTRUMENTS LTD

FOR NEW AND SECONDHAND

Microscopes, Telescopes, Cameras, Binoculars and Accessories

REPAIRS UNDERTAKEN. BEST PRICES PAID FOR MODERN EQUIPMENT

NOW READY

Catalogue of Dissecting Instruments, Slide Boxes, Stains, Books and Sundries

Write to Department D.1 for your copy

244 HIGH HOLBORN, LONDON, W.C.1 (HOLborn 1427)

(A subsidiary of C. Baker of Holborn Ltd)

Study at Home

for London University

B.Sc.
Degree

● Interesting careers with excellent prospects are open to Science graduates both in industry and in teaching. You may prepare for the London B.Sc. at home through the postal courses provided by Wolsey Hall (Est. 1894). Fees are moderate and may be paid by instalments. Tuition can also be arranged in some subjects for M.Sc. (Maths.). **Prospectus** from C. D. Parker, M.A., B.Sc., LL.D., Director of Studies, Dept. WM 81,

WOLSEY HALL, OXFORD

The Golder MICROFLEX Eyepiece Camera

with reflex action by first-surface aluminised mirror, shutter operated by 9 in. cable release, and taking both plates and cut-film, 3½ in. × 2½ in. Suitable for all microscopes taking standard 23·3 mm. eyepieces.

Leaflet M65 containing full information from

ALBERT GOLDER & CO.
137 DAIRSIE RD., ELTHAM, LONDON, S.E.9
Phone: ELTham 5126

VACUUM TECHNOLOGY

"SPEEDIVAC"
TRADE MARK

VACUUM UNITS FOR FACTORY SYSTEMS OR INDIVIDUAL USERS

MULTI-POINT VACUUM SYSTEMS

For piping high vacuum to remote parts of the factory from a central pump. Self-contained. Any number of outlet points supplied.

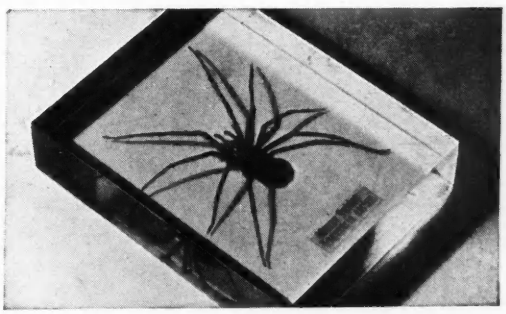
ROTARY VACUUM PUMPS

For high vacua up to 0·002 mm. Hg at high pumping speeds. Unaffected by condensable vapours. All capacities.

WATER JET PUMPS

Supplies a continuous vacuum of 12–15 mm. Hg from ordinary water tap. Special high speed jets and non-return valves.

EDWARDS HIGH VACUUM LTD
MANOR ROYAL · CRAWLEY · SUSSEX
CRAWLEY 1500 (10 lines) EDCOHIVAC, Crawley



Preserve your specimens in solid transparent plastic

Biological specimens—insects, small skeletons, fish, etc., embedded in a block of Ceemar plastic are completely visible and can be handled indefinitely without injury—ideal for both school classes and advanced students. You prepare them yourselves using the Ceemar kit—a simple technique for any laboratory worker.

Trial kit 35s. complete with full instructions. Post paid (in the United Kingdom)

CEEMAR EMBEDDING KIT

Obtainable from the principal laboratory suppliers or direct from
E. M. CROMWELL & Co. Ltd., Rye St., Bishop's Stortford, Herts.

A small, controlled earth tremor is one of the geophysicist's most important tools in his quest for the world's crude oil resources.

These earth tremors are set off by small explosive charges buried in the ground.

Earthquakes to order

When the geophysicist explodes a charge, "shock waves" are sent downwards into the earth, and are reflected by layers of rock deep in the earth's crust. The waves that return to the surface are picked up on sensitive receivers. By measuring the time between the detonation of the charge and the return of the various "echoes", the geophysicist can glean valuable information about the strata beneath him. Indeed, he can often draw an "underground map" of the area and so predict where there might be oil.

The Nobel Division of Imperial Chemical Industries Ltd. is an important supplier of the specialised explosives and detonators used in 'Seismic Prospecting', as the technique is called, and their prospecting explosives have won an enviable reputation for reliability in the far-off tropical and desert lands where oil is found.

Thus, and in a thousand kindred ways, I.C.I.'s research and production are serving the Nation.

ICI

d.

e earth, and are
ust.
sensitive

',
tation